Summary
Overview of the Jet / Surface Interaction Test (JSIT1)

This material was presented at the Acoustics Technical Working Group Meeting on April 22, 2011. It provides an overview of an experiment called the Jet / Surface Interaction Test which was conducted to expand the database available regarding how a planar surface interacts with a jet to shield and/or enhance the jet noise. This presentation focuses on data obtained during Phase 1 of the test, JSIT1, which was conducted using the Small Hot Jet Acoustic Rig located in the Aeroacoustics Propulsion Lab at NASA GRC during January and February, 2011. A second phase of the test, JSIT2, is planned for 2012.

There were two parts of the phase 1 test. In part 1, known as the shielding surface part of the test, a planar surface was placed between the jet and the microphones. In part 2, the reflecting surface part of the test, the surface was placed on the opposite side of the jet so that the jet noise was free to reflect off the surface toward the microphones. Phased array, pressure sensitive paint, and far field acoustic data obtained during JSIT1 are presented. The phased array data illustrate how the jet noise is blocked by the shielding surface. It also shows that the low frequency scrubbing noise generated when the surface is impacted by the jet comes predominantly from the surface trailing edge. The far field data show the trailing edge noise to be a dipole source. The pressure sensitive paint data show how the pressure distribution on the surface varies as the surface is traversed toward jet.

Overview of the Jet / Surface Interaction Test (JSIT1)

Gary Podboy

Cliff Brown

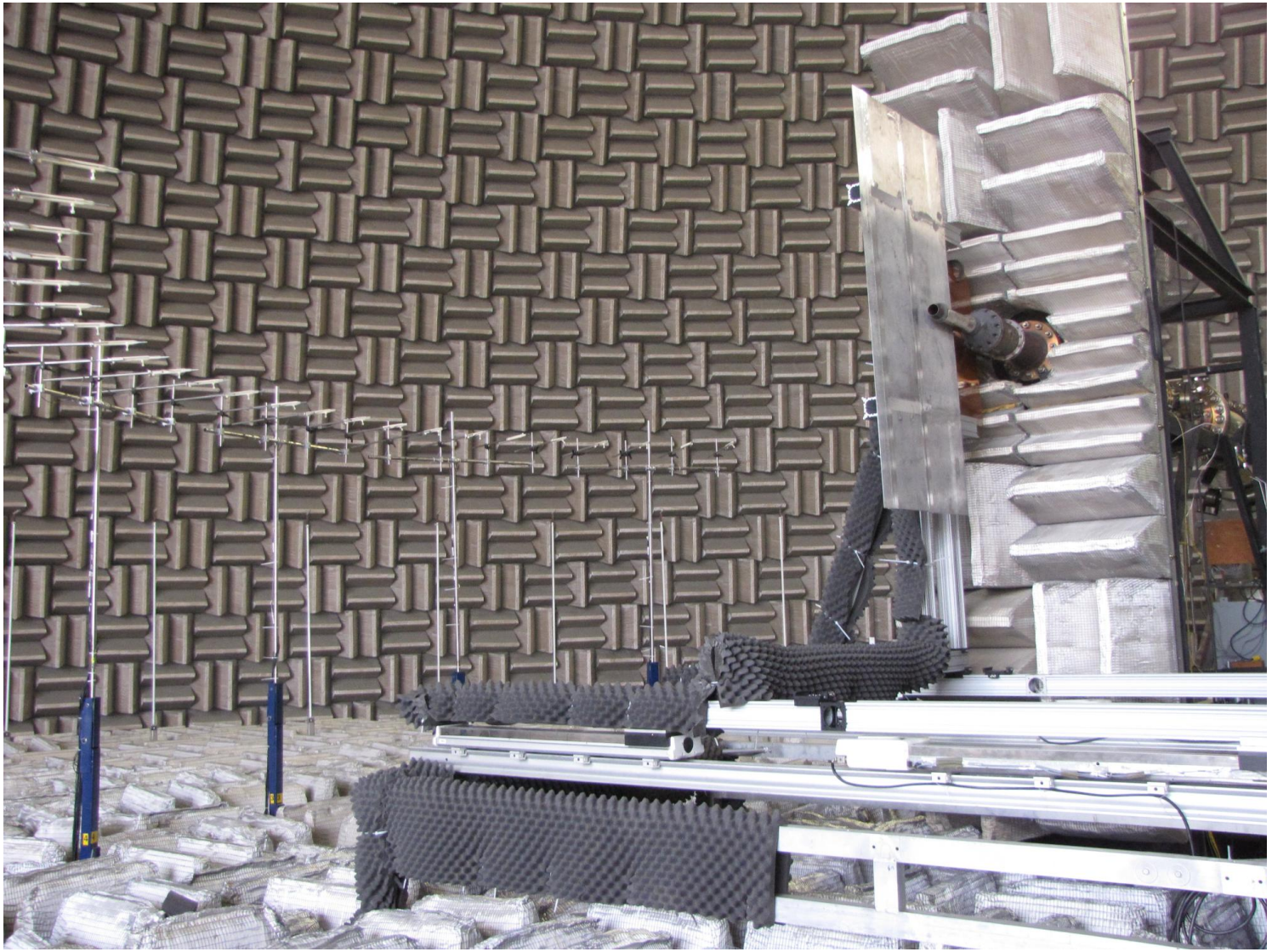
Tim Bencic

Support Provided by the Subsonic Fixed Wing Program

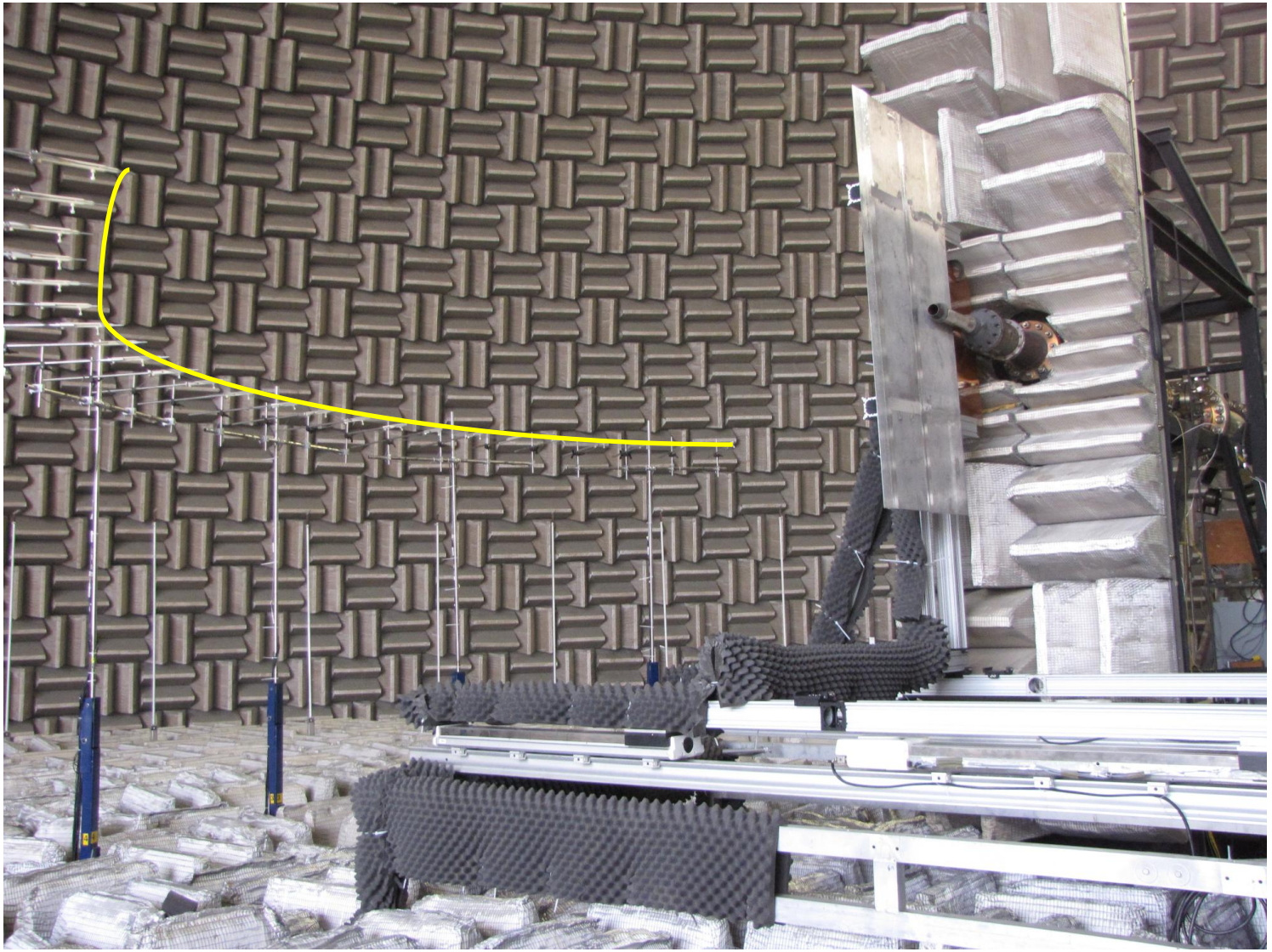
Purpose of JSIT1

Parametric study to expand the database available regarding how and where a planar surface can 1) shield and/or 2) enhance jet noise

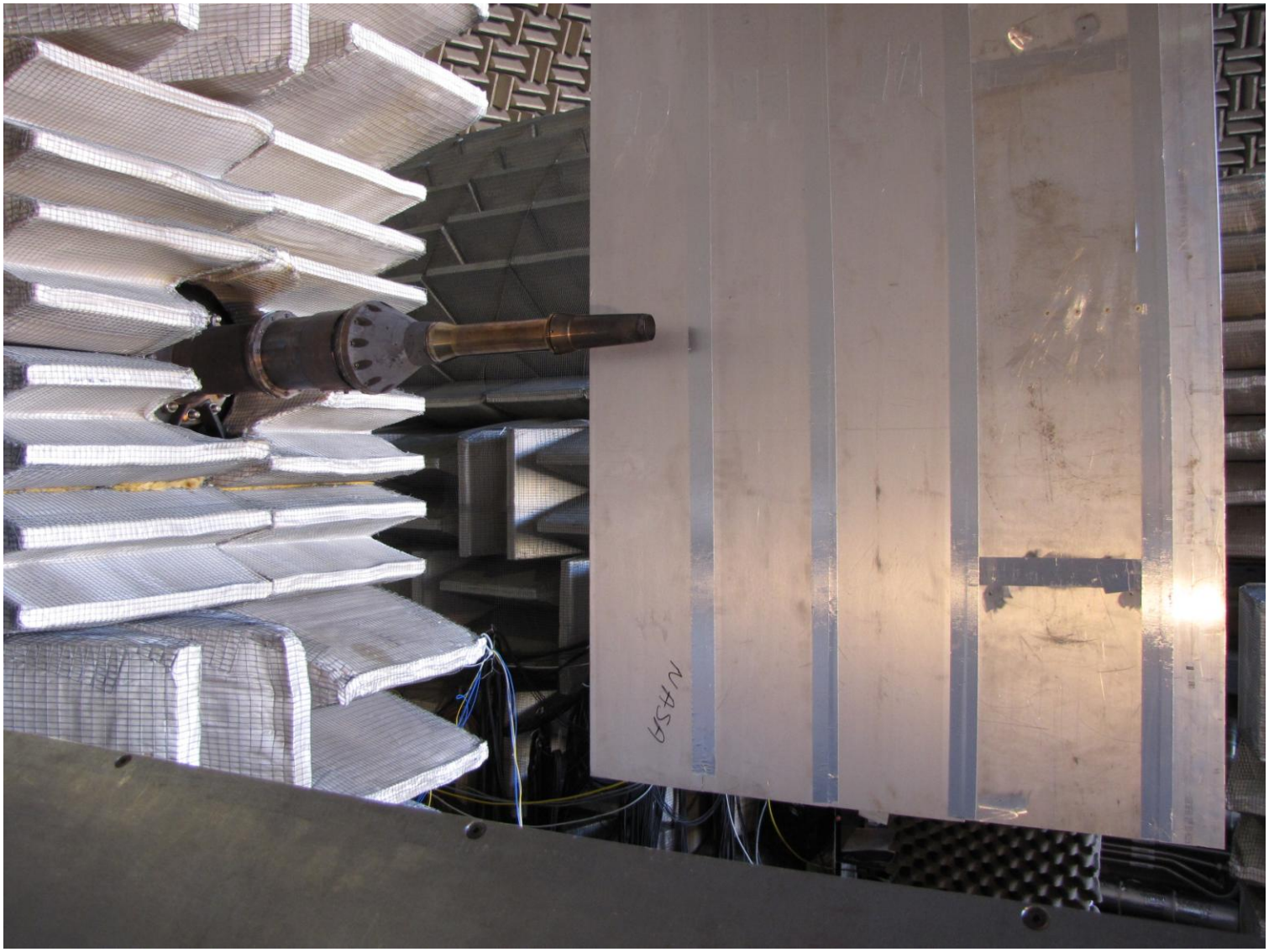
Shielding Surface



Shielding Surface



Reflecting Surface

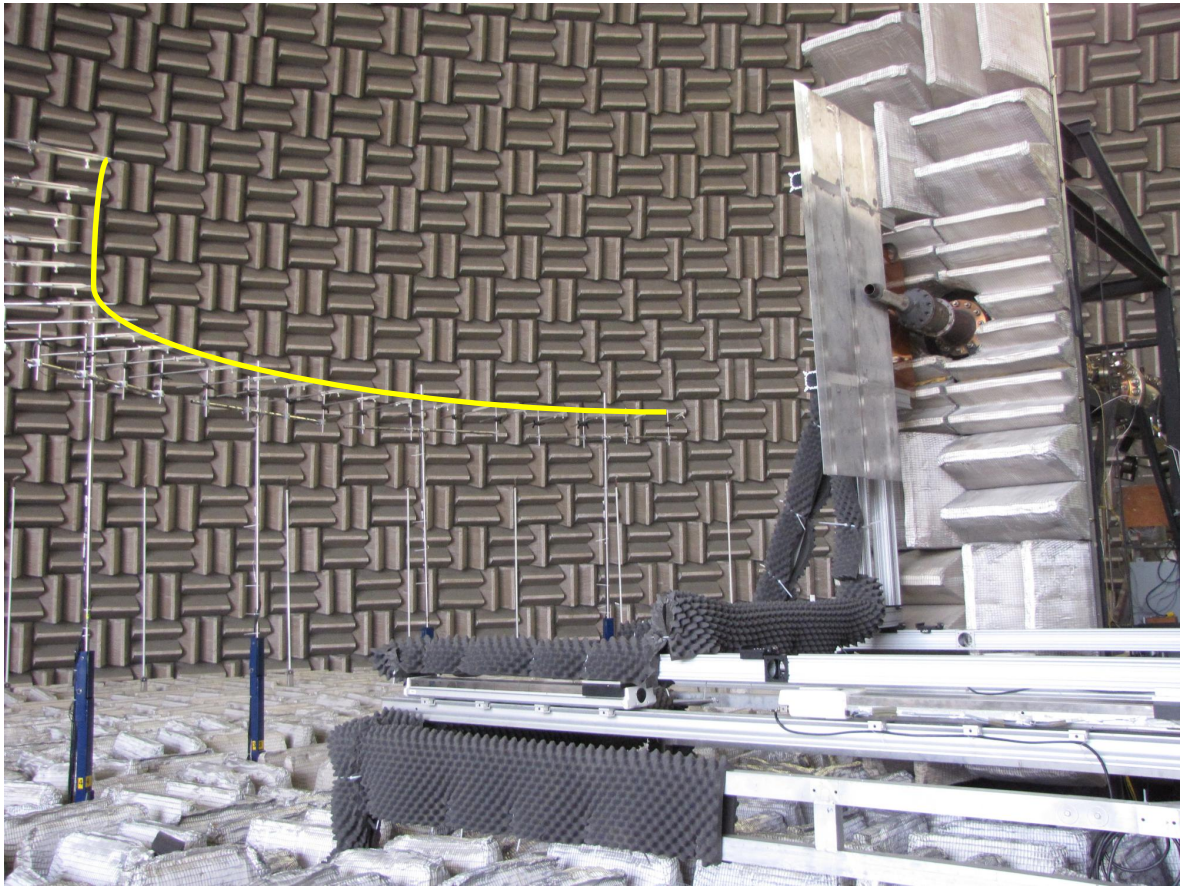


Parameters

1) Axial Dimension of Surface
2) Radial Location of Surface
3) Jet Operating Condition

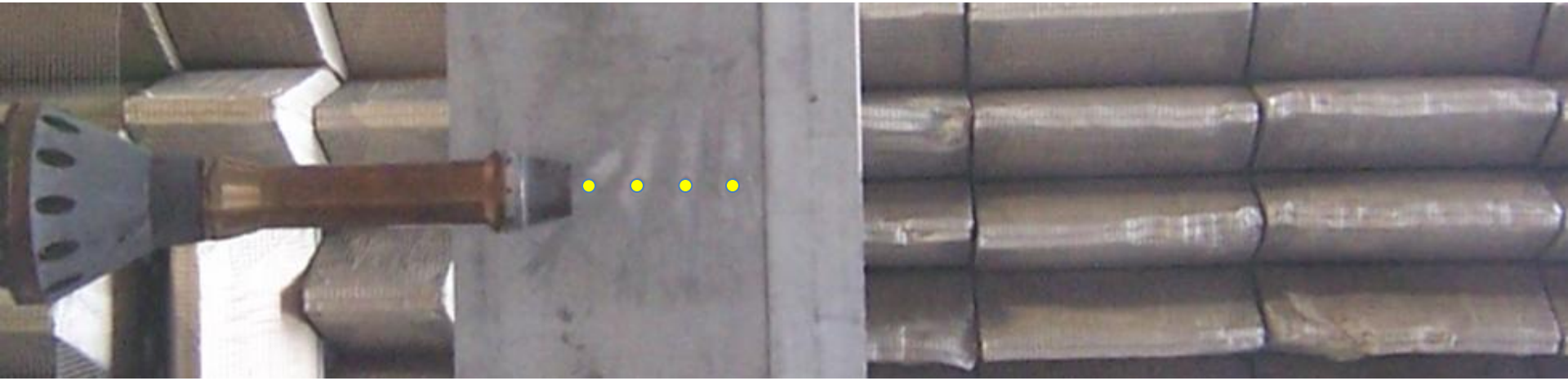
4 Types of Data Acquired

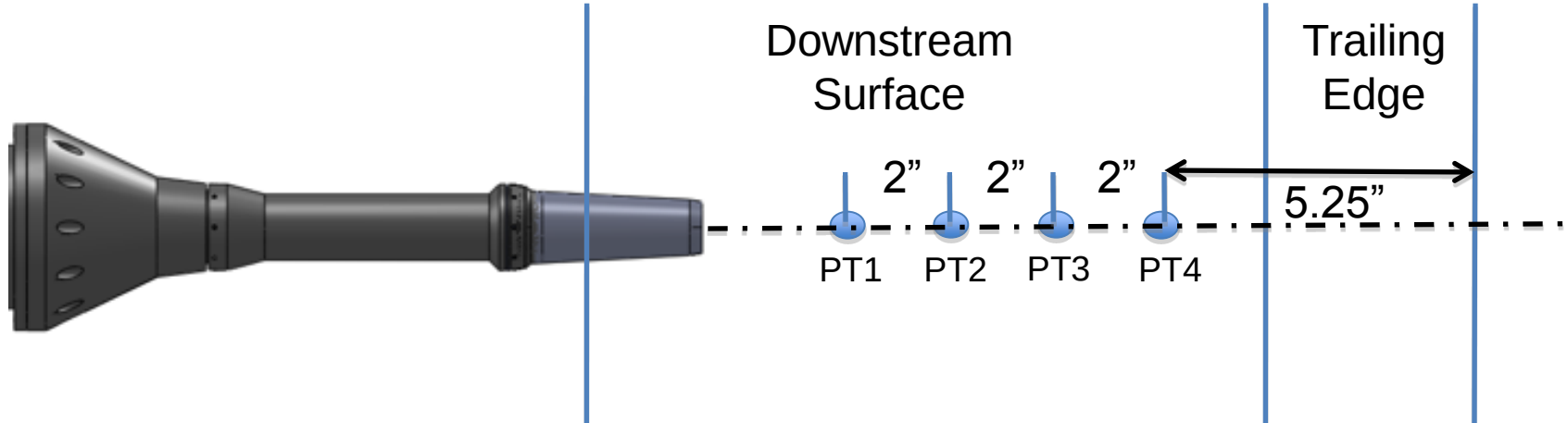
1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint



4 Types of Data Acquired

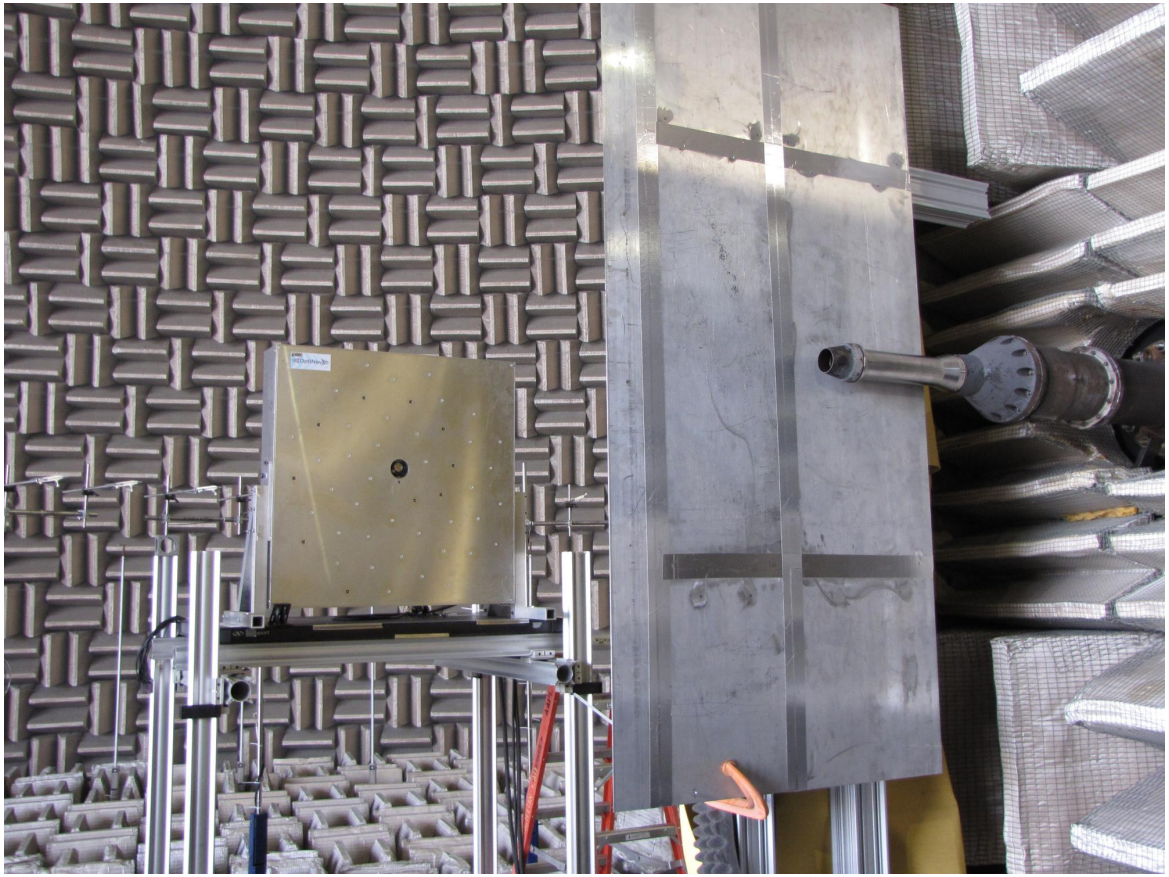
1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint





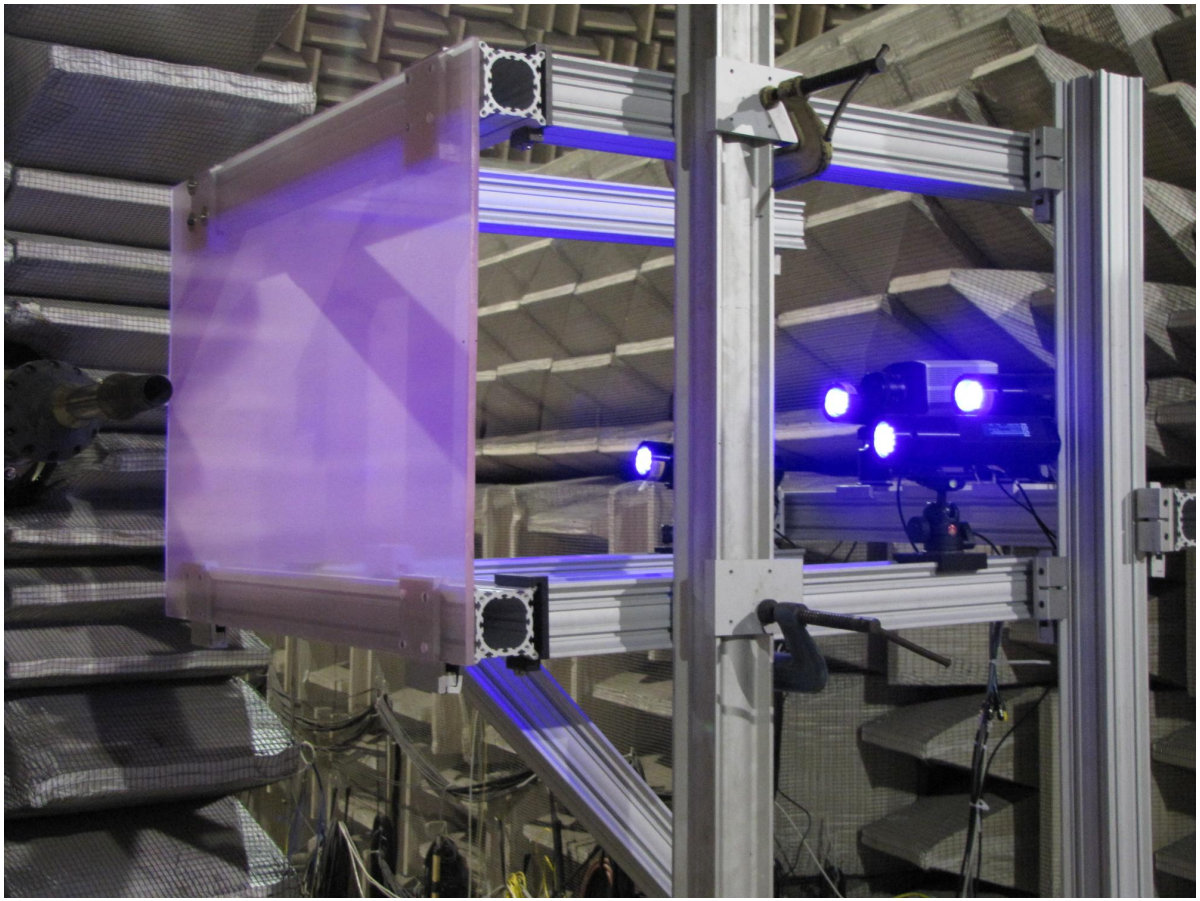
4 Types of Data Acquired

1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint

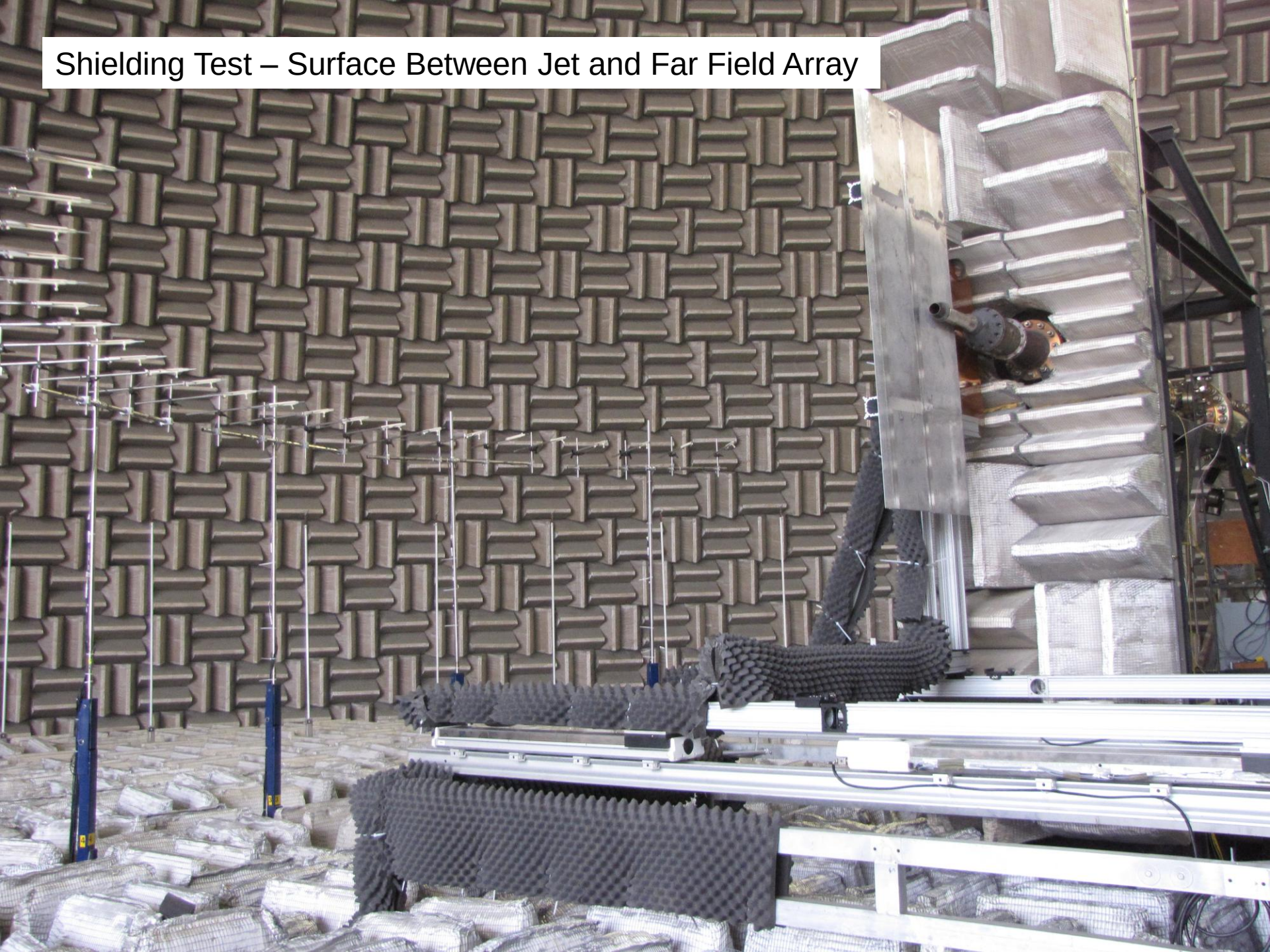


4 Types of Data Acquired

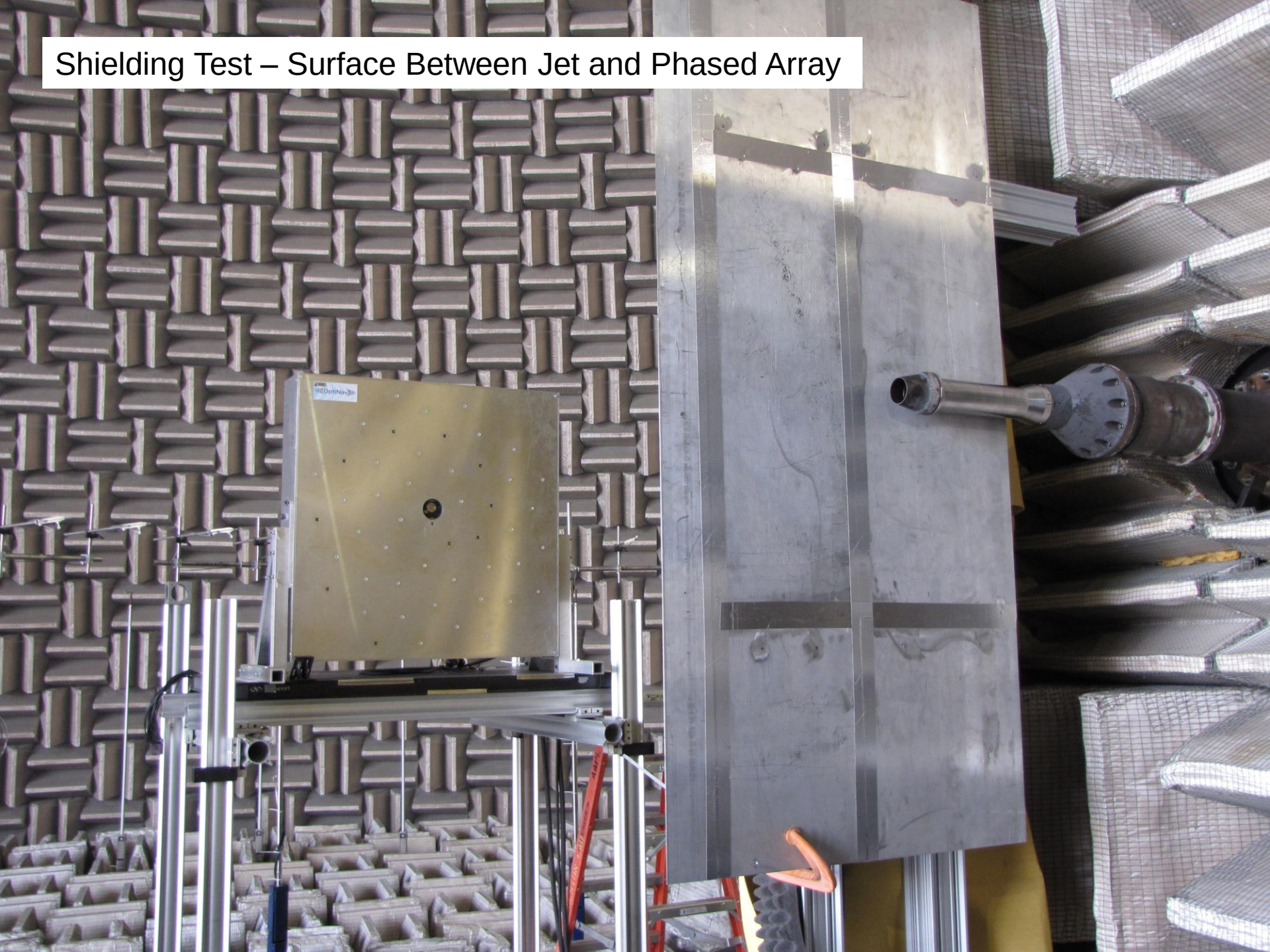
1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint



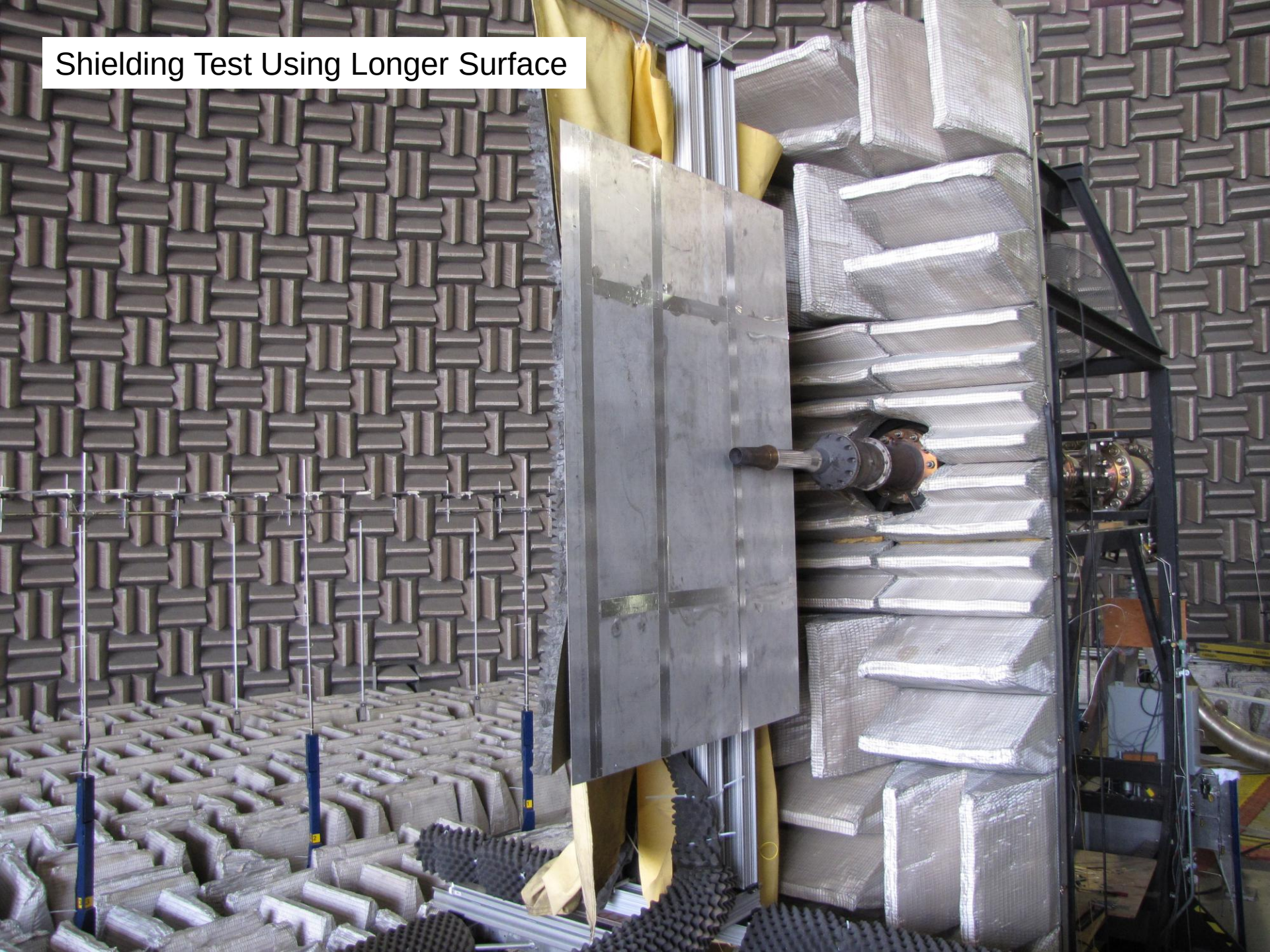
Shielding Test – Surface Between Jet and Far Field Array



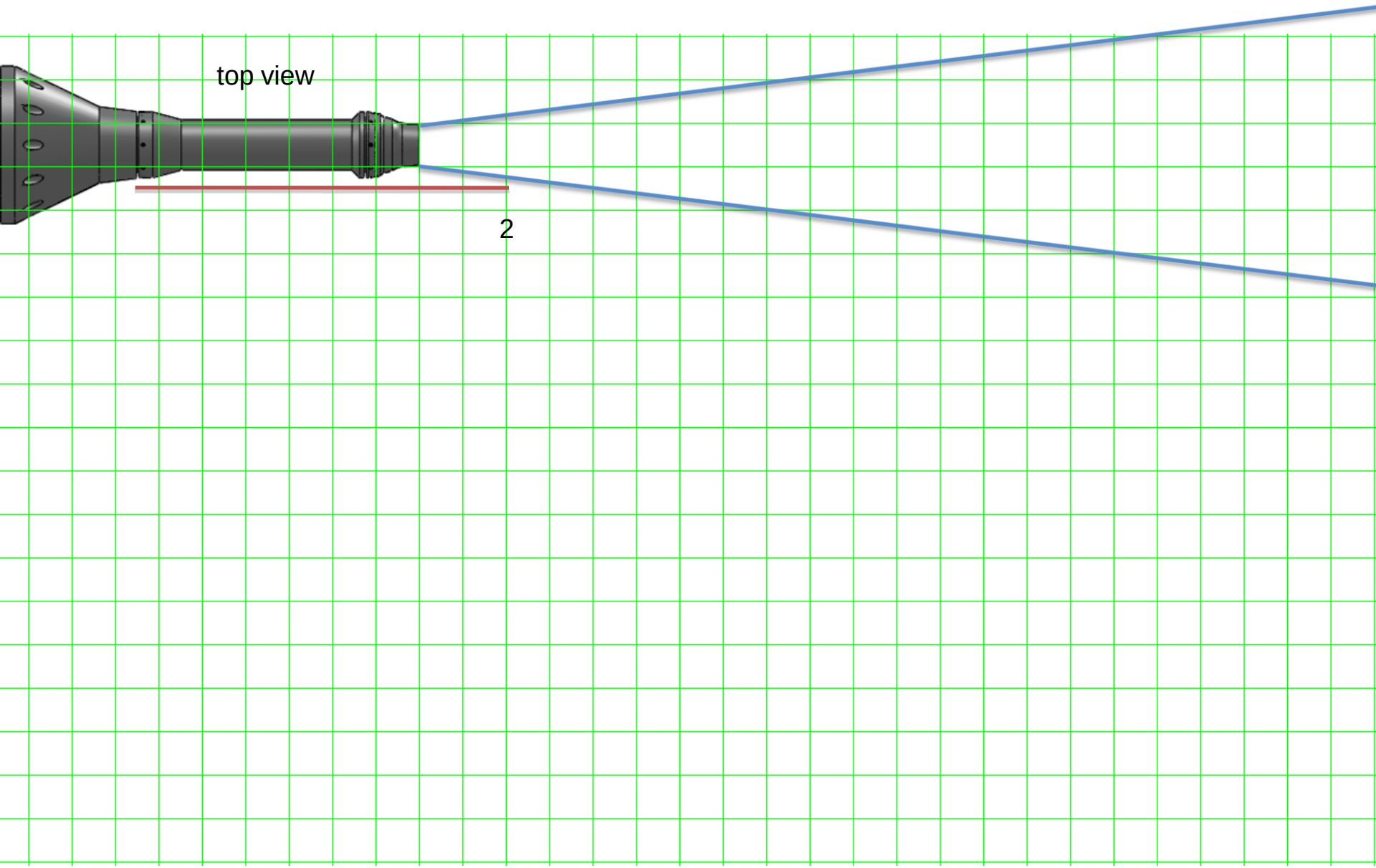
Shielding Test – Surface Between Jet and Phased Array



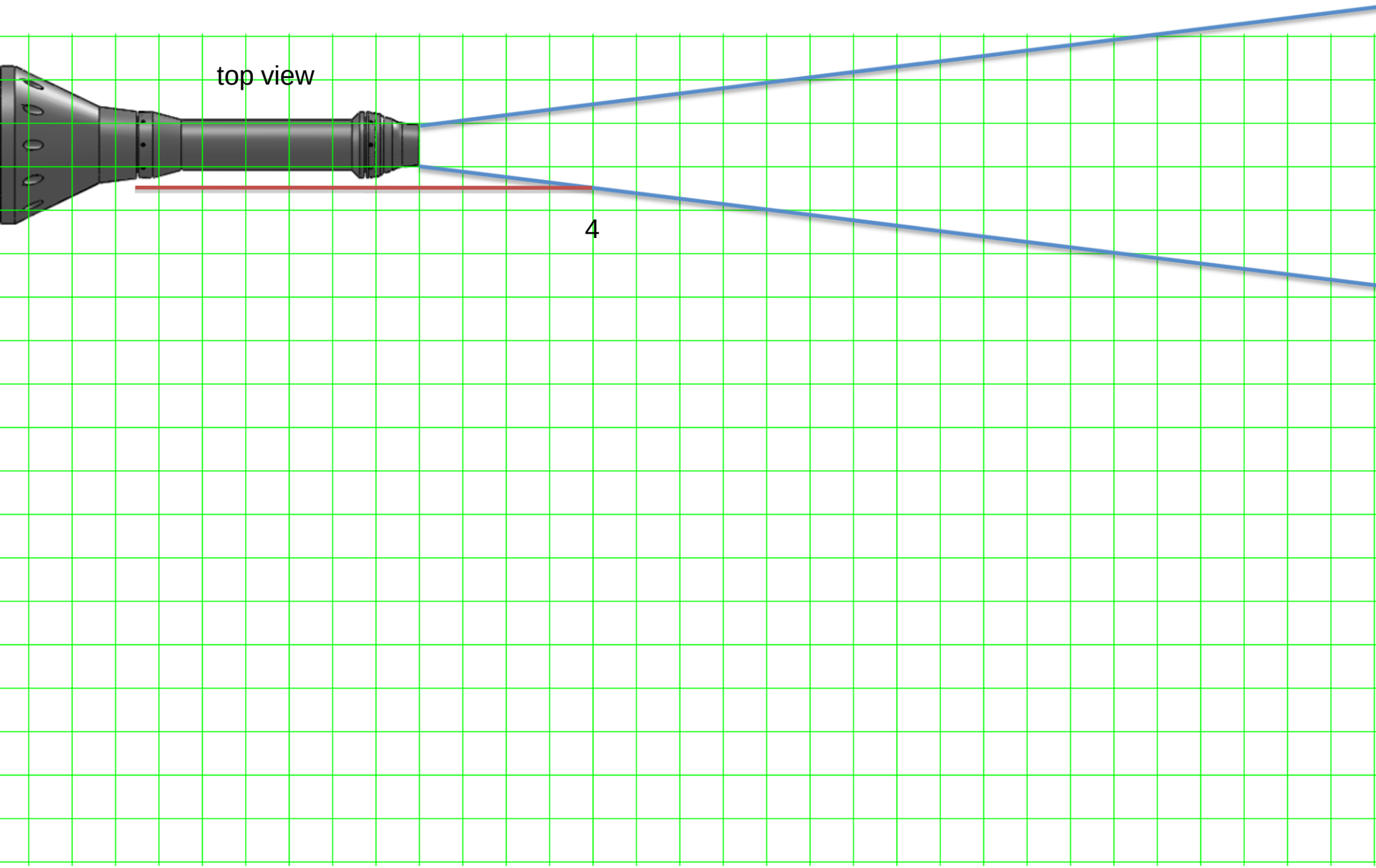
Shielding Test Using Longer Surface



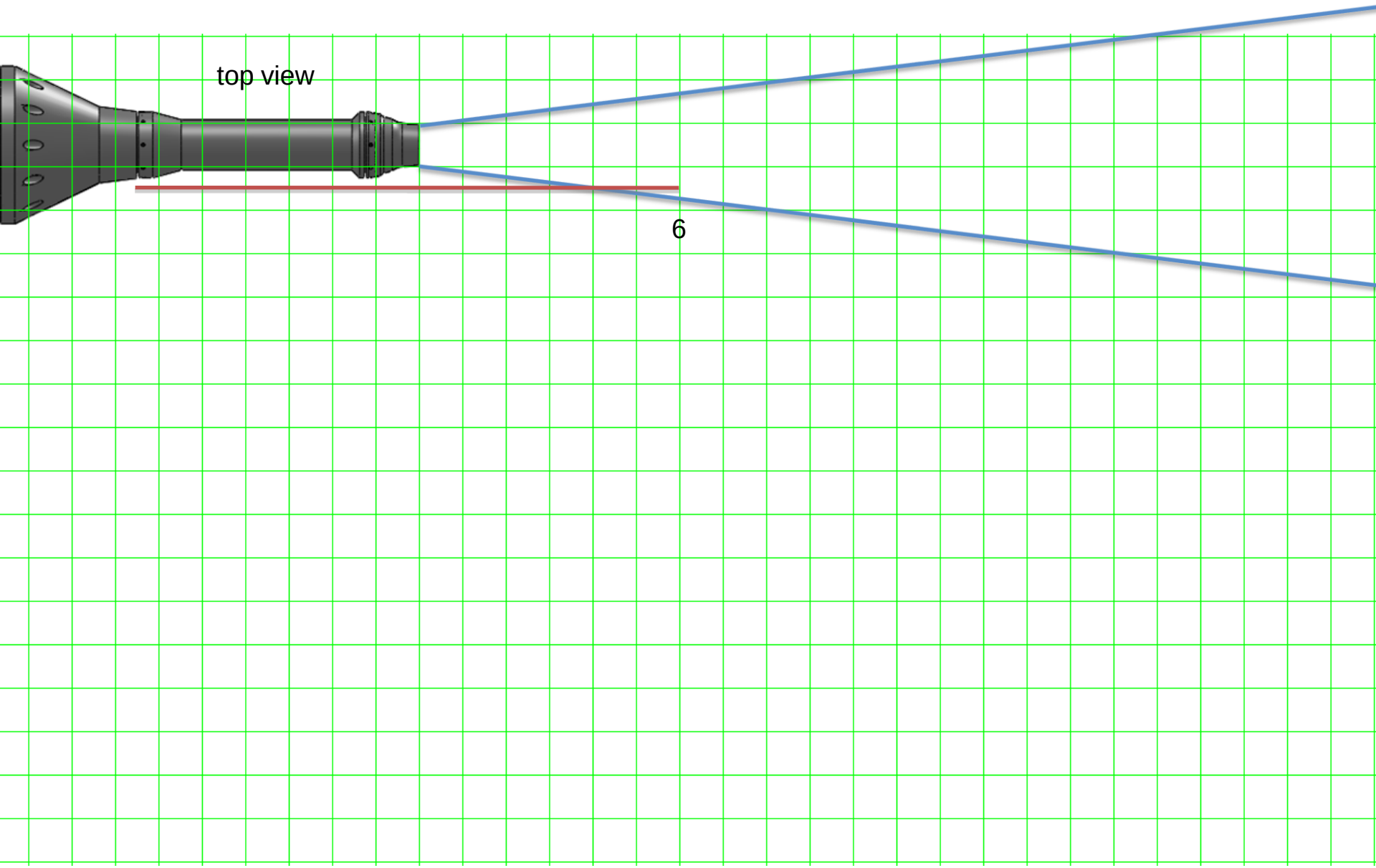
Baseline Round Convergent Nozzle, smc000 Shield TE @ 2 Diams



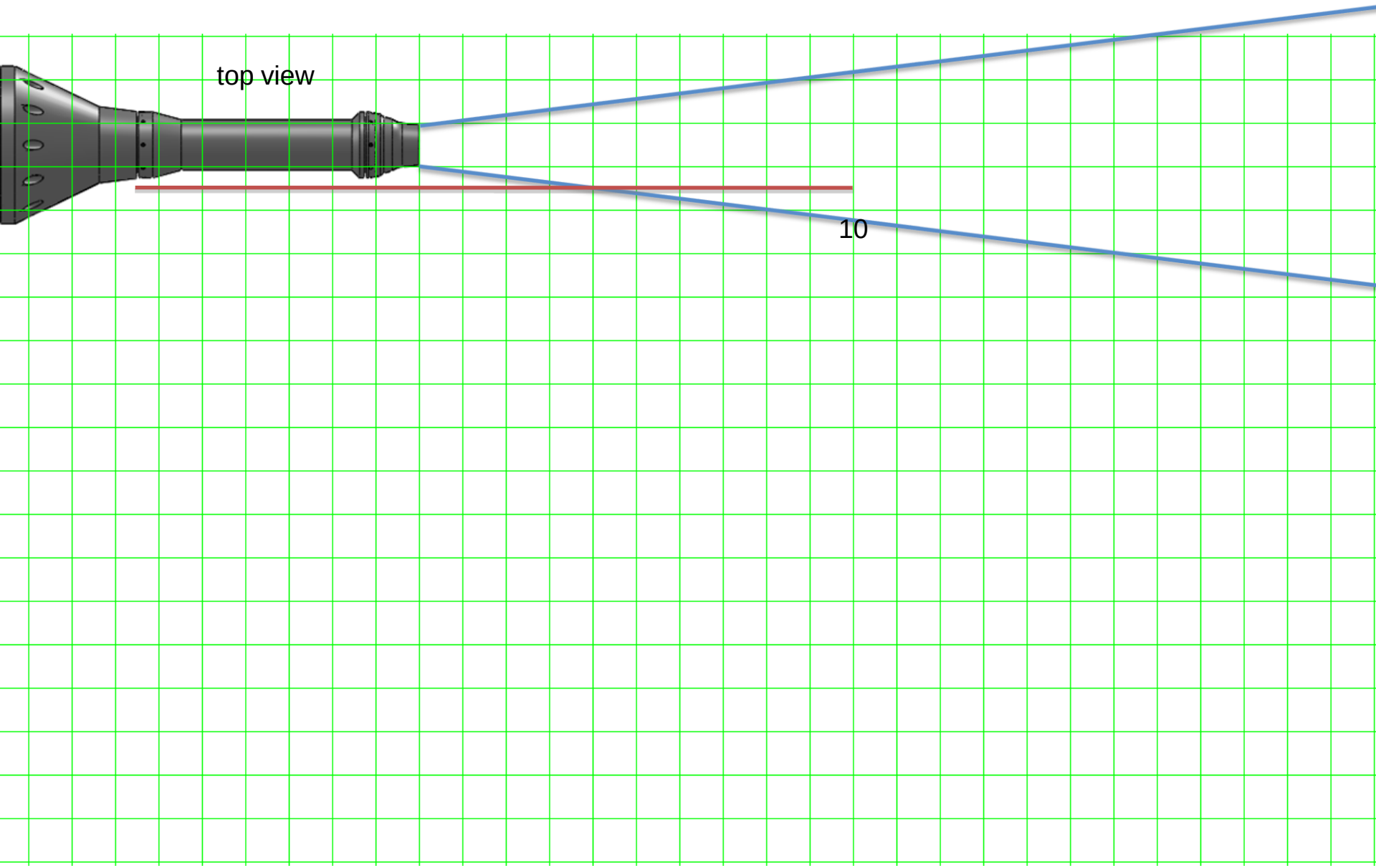
Baseline Round Convergent Nozzle, smc000 Shield TE @ 4 Diams



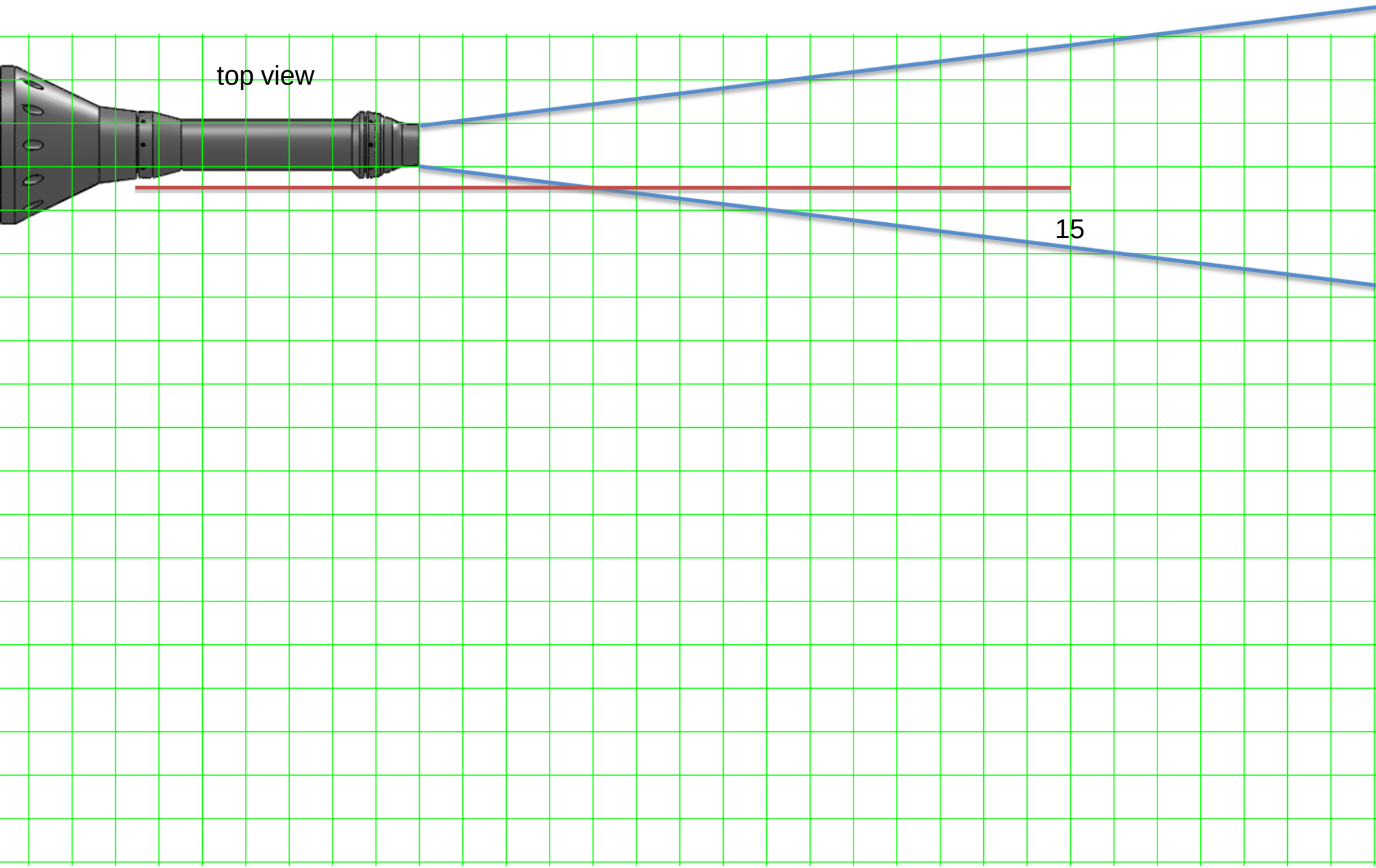
Baseline Round Convergent Nozzle, smc000 Shield TE @ 6 Diams



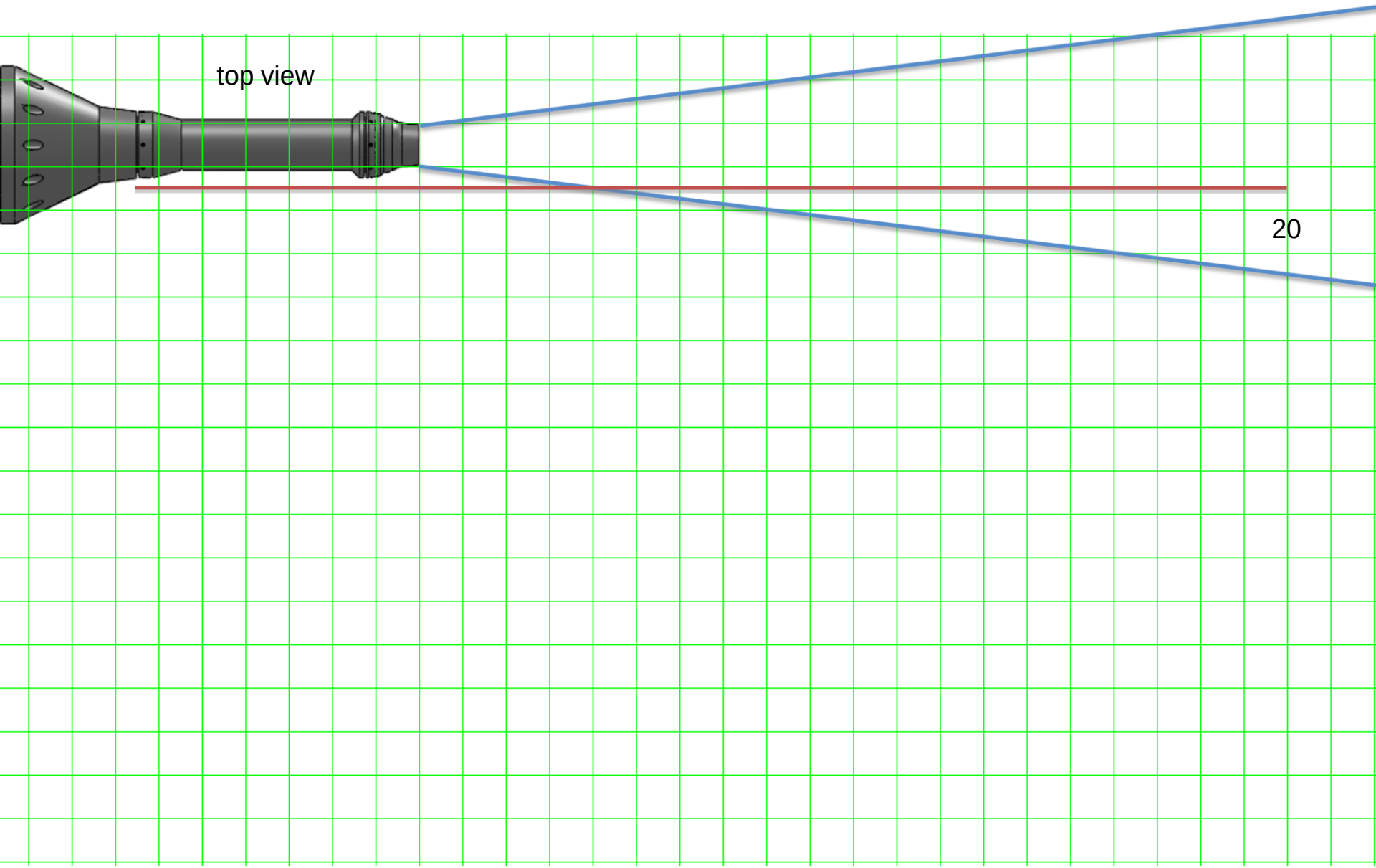
Baseline Round Convergent Nozzle, smc000 Shield TE @ 10 Diams



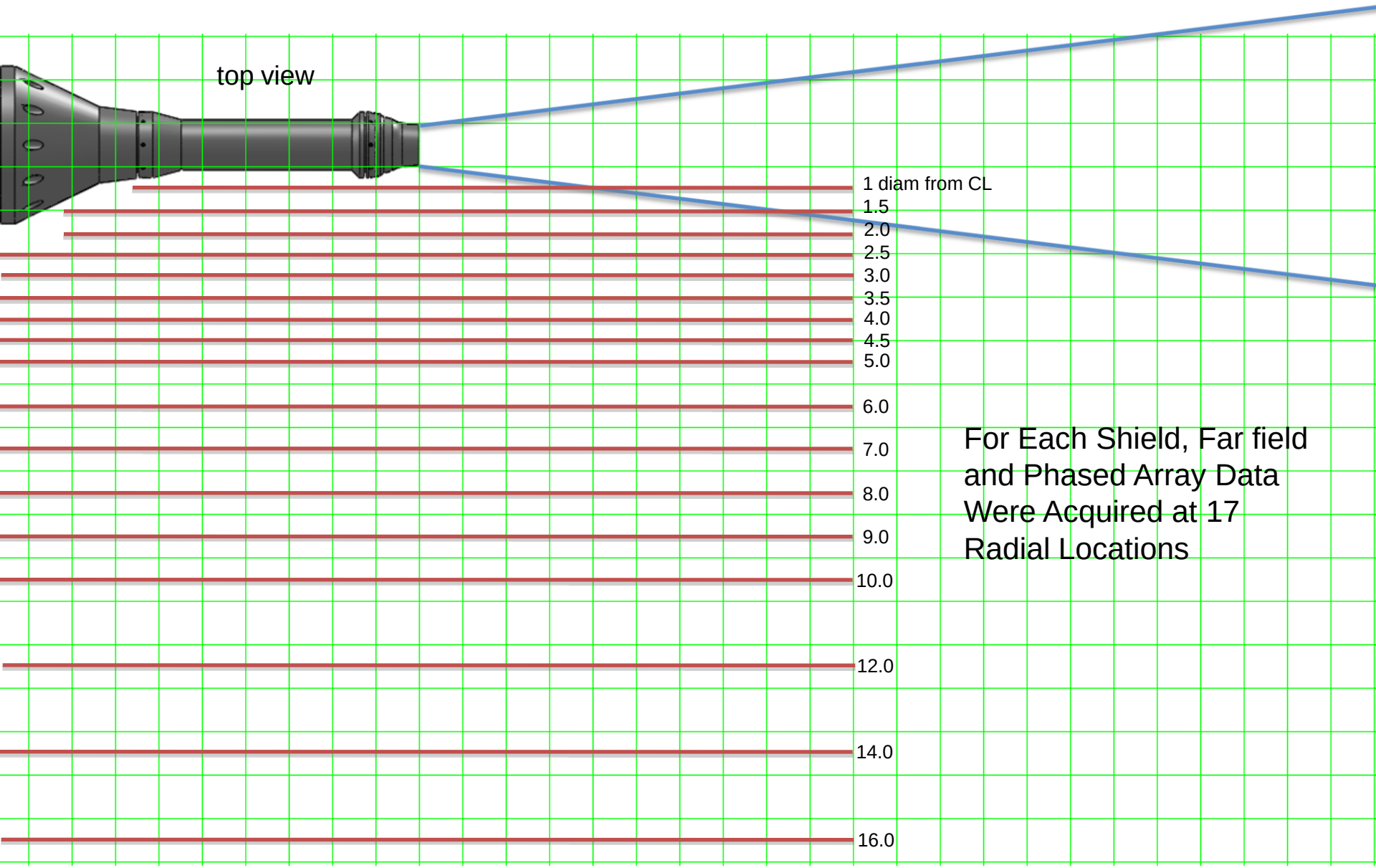
Baseline Round Convergent Nozzle, smc000 Shield TE @ 15 Diams



Baseline Round Convergent Nozzle, smc000 Shield TE @ 20 Diams



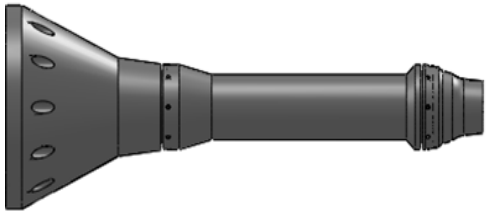
Baseline Round Convergent Nozzle, smc000 Shield TE @ 10 Diams



For Each Shield, Far field and Phased Array Data Were Acquired at 17 Radial Locations

Shielding Test

Baseline Round Convergent Nozzle, smc000

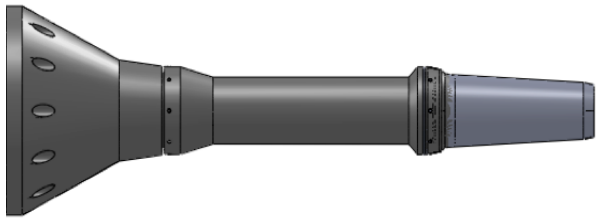


6 Axial X 17 Radial X 5 Set Points = 510

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
27	1.36	1.764	0.9	0.68
46	1.227	2.7	0.9	0.55
9010	3.182	0.74	1.18	1.40

Shielding Test

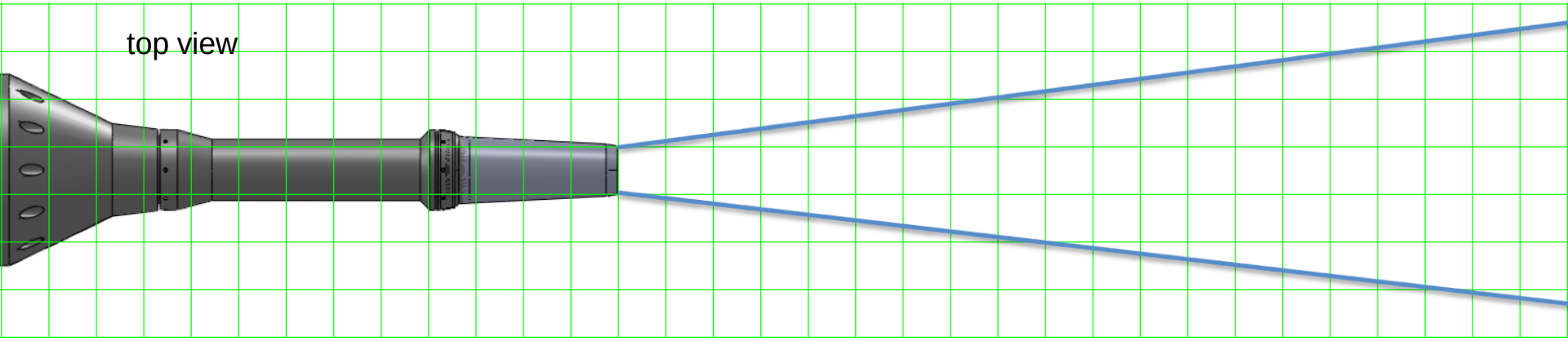
Convergent Divergent Nozzle, smc016



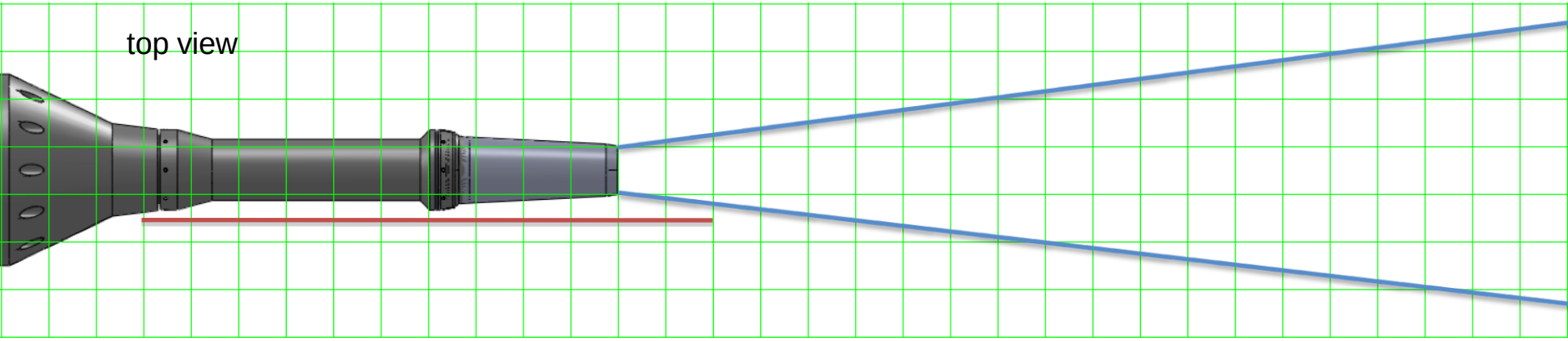
6 Axial X 17 Radial X 3 Set Points = 306

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

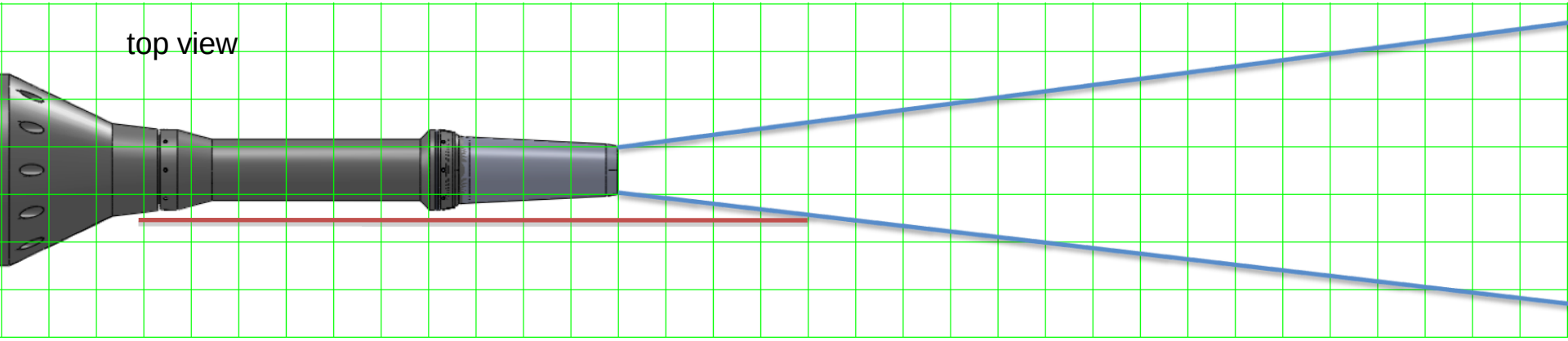
No Shield, Convergent Divergent Nozzle



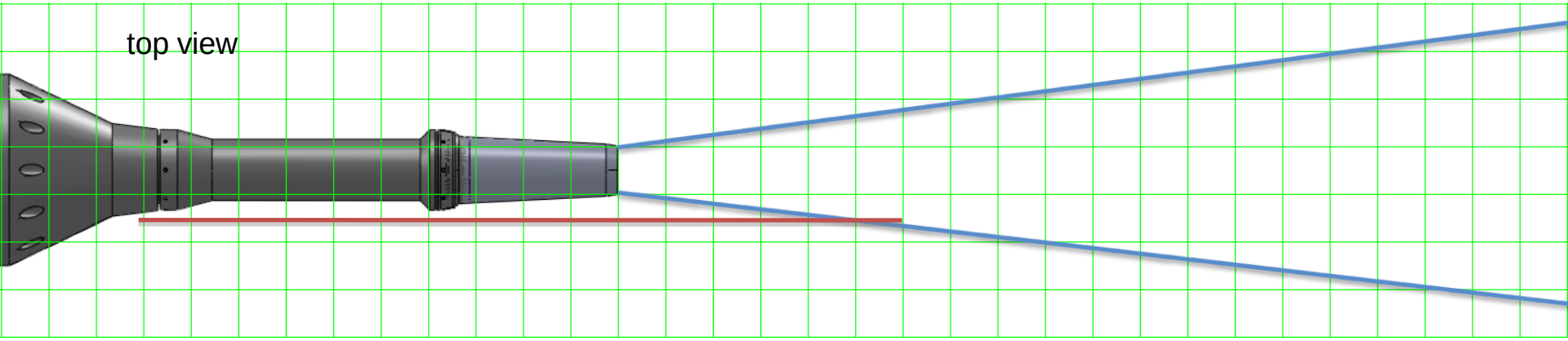
Shielding at 2 Diameters, Convergent Divergent Nozzle



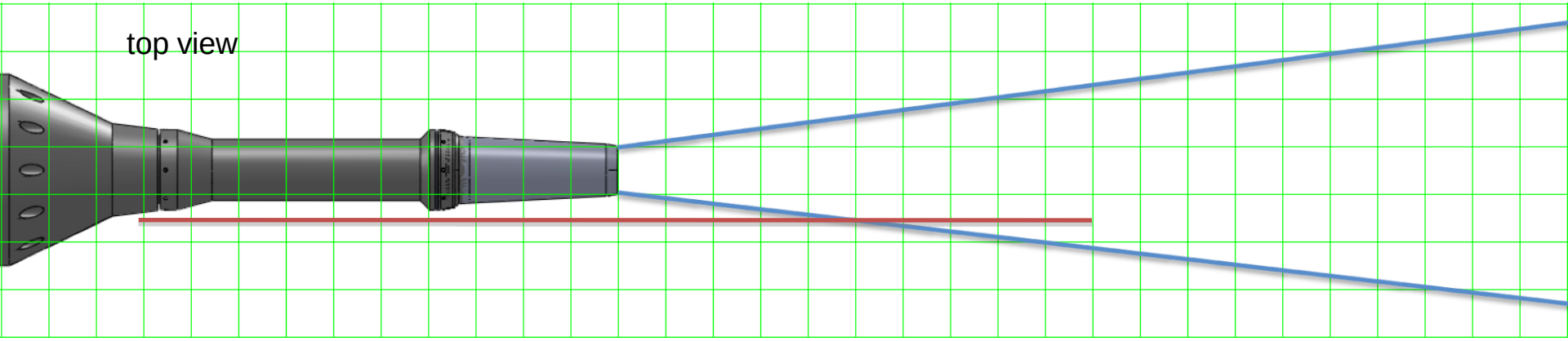
Shielding at 4 Diameters, Convergent Divergent Nozzle



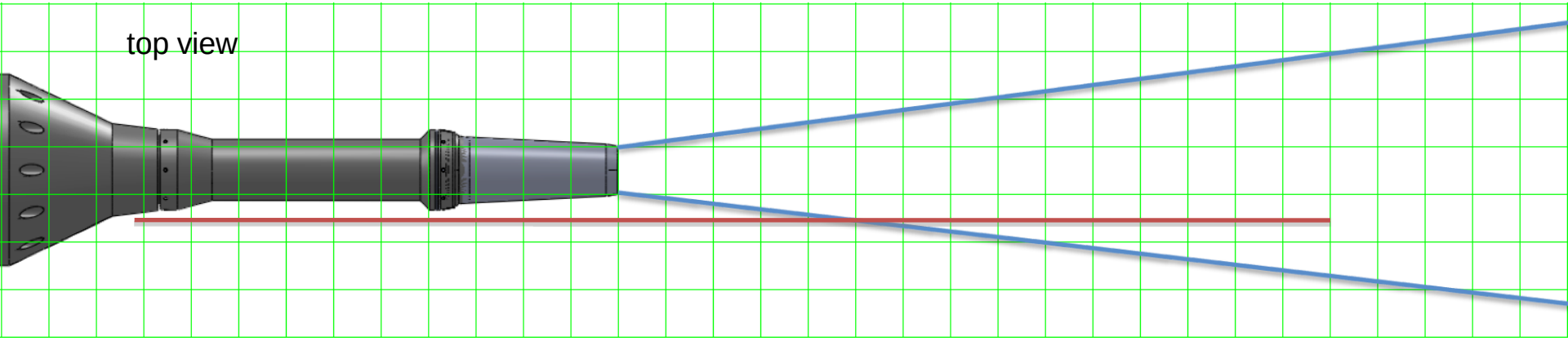
Shielding at 6 Diameters, Convergent Divergent Nozzle



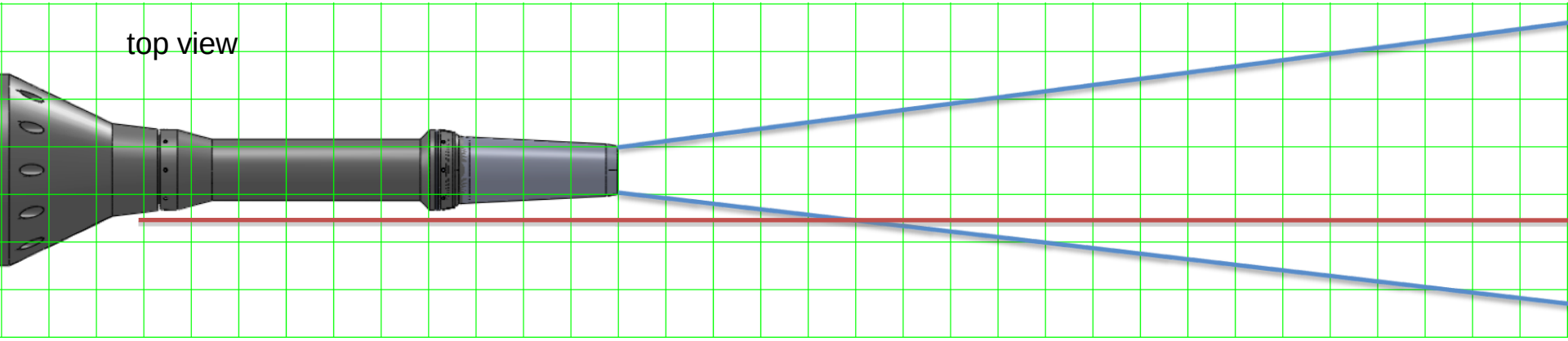
Shielding at 10 Diameters, Convergent Divergent Nozzle



Shielding at 15 Diameters, Convergent Divergent Nozzle

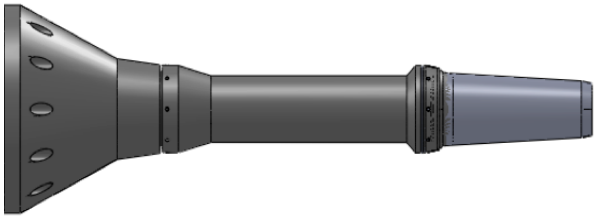


Shielding at 20 Diameters, Convergent Divergent Nozzle



Shielding Test

Convergent Divergent Nozzle, smc016

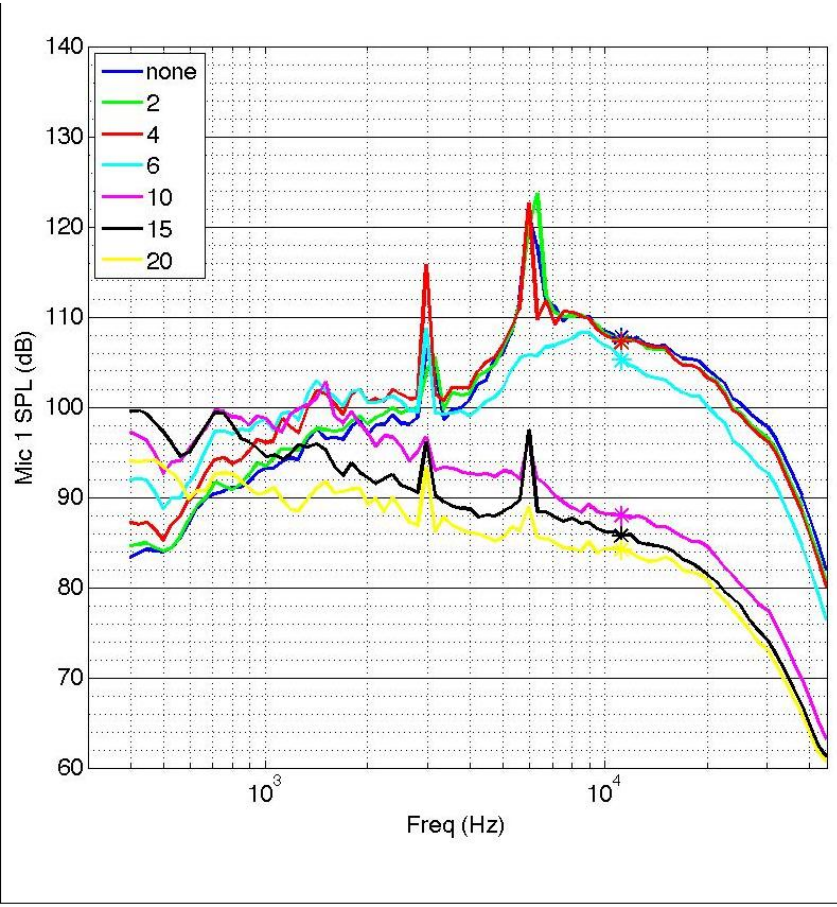


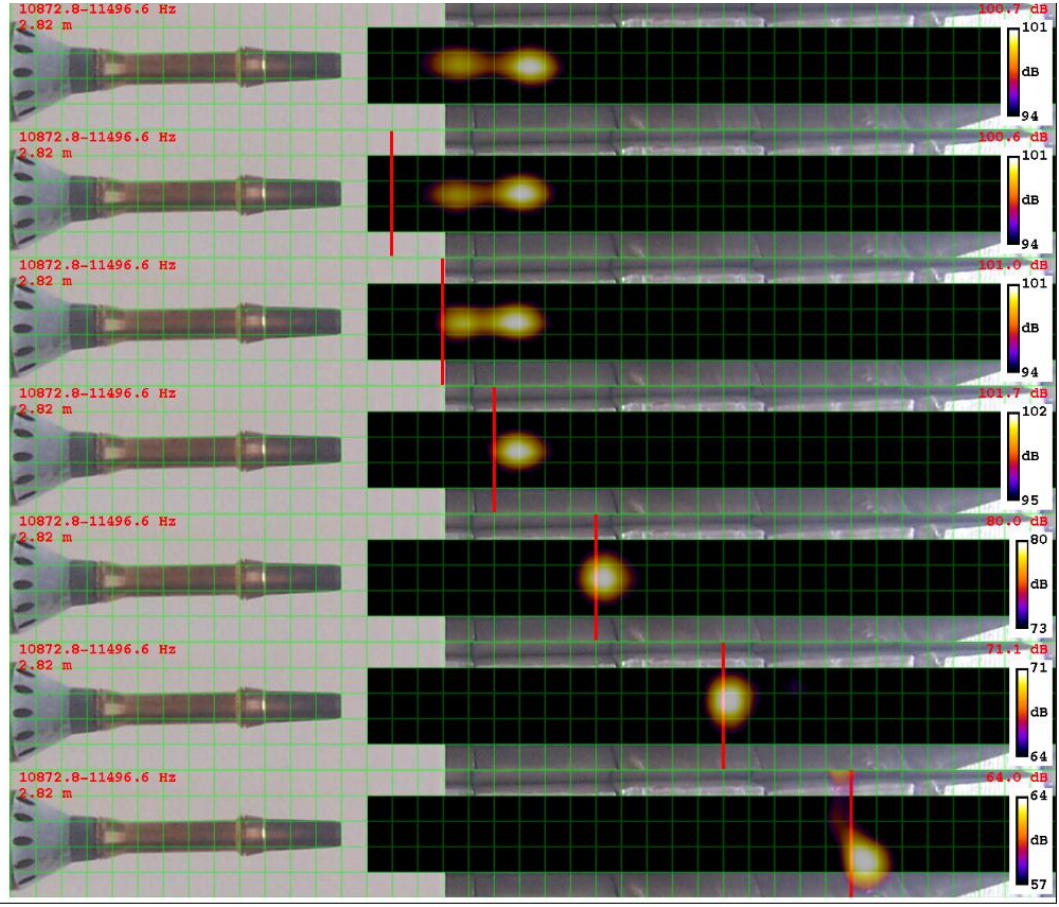
6 Axial X 17 Radial X 3 Set Points

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

Example Shielding Data

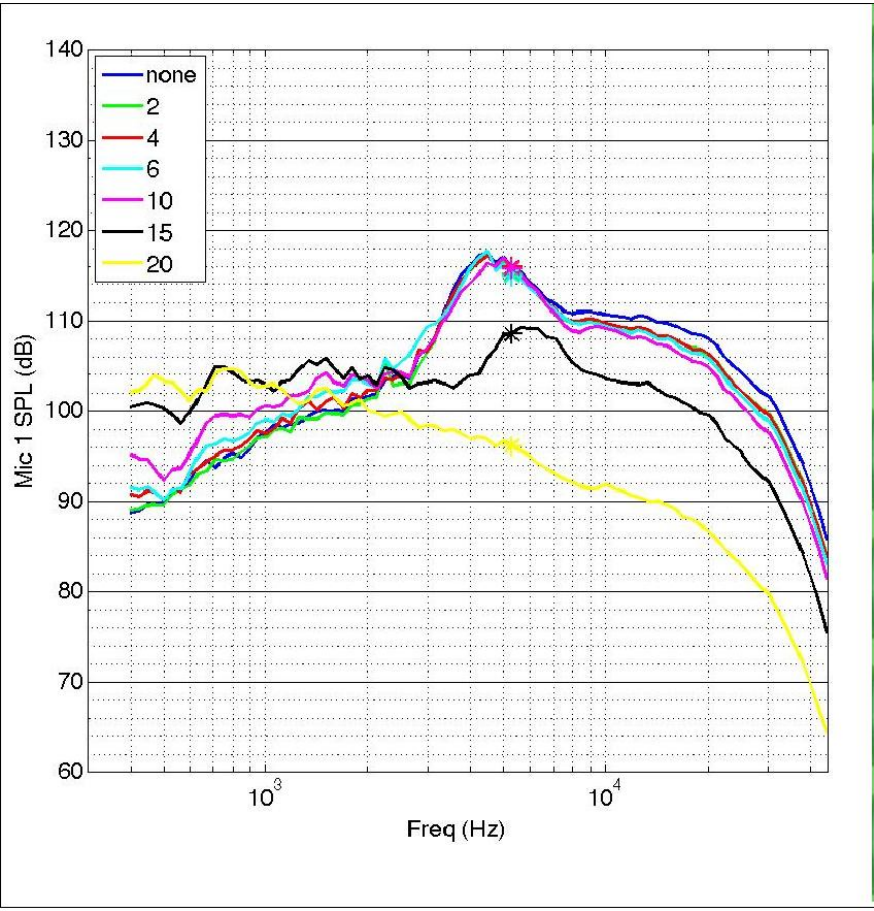
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded

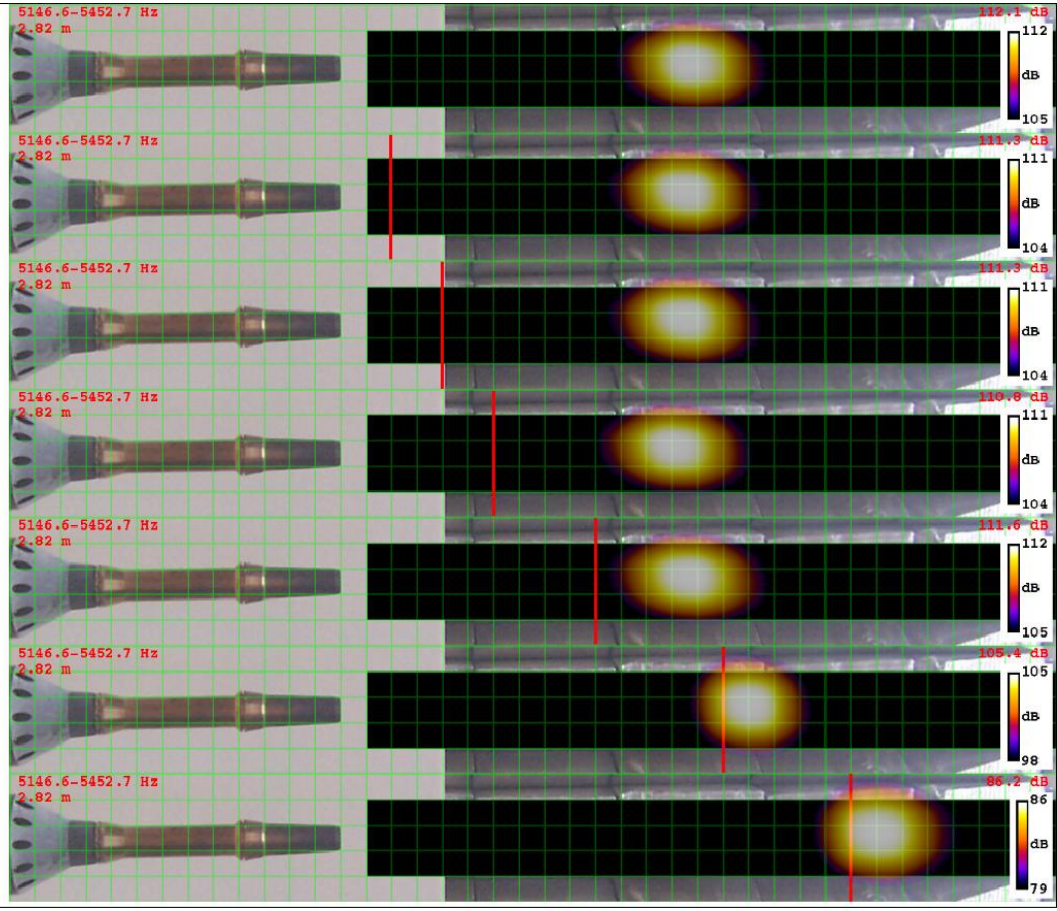


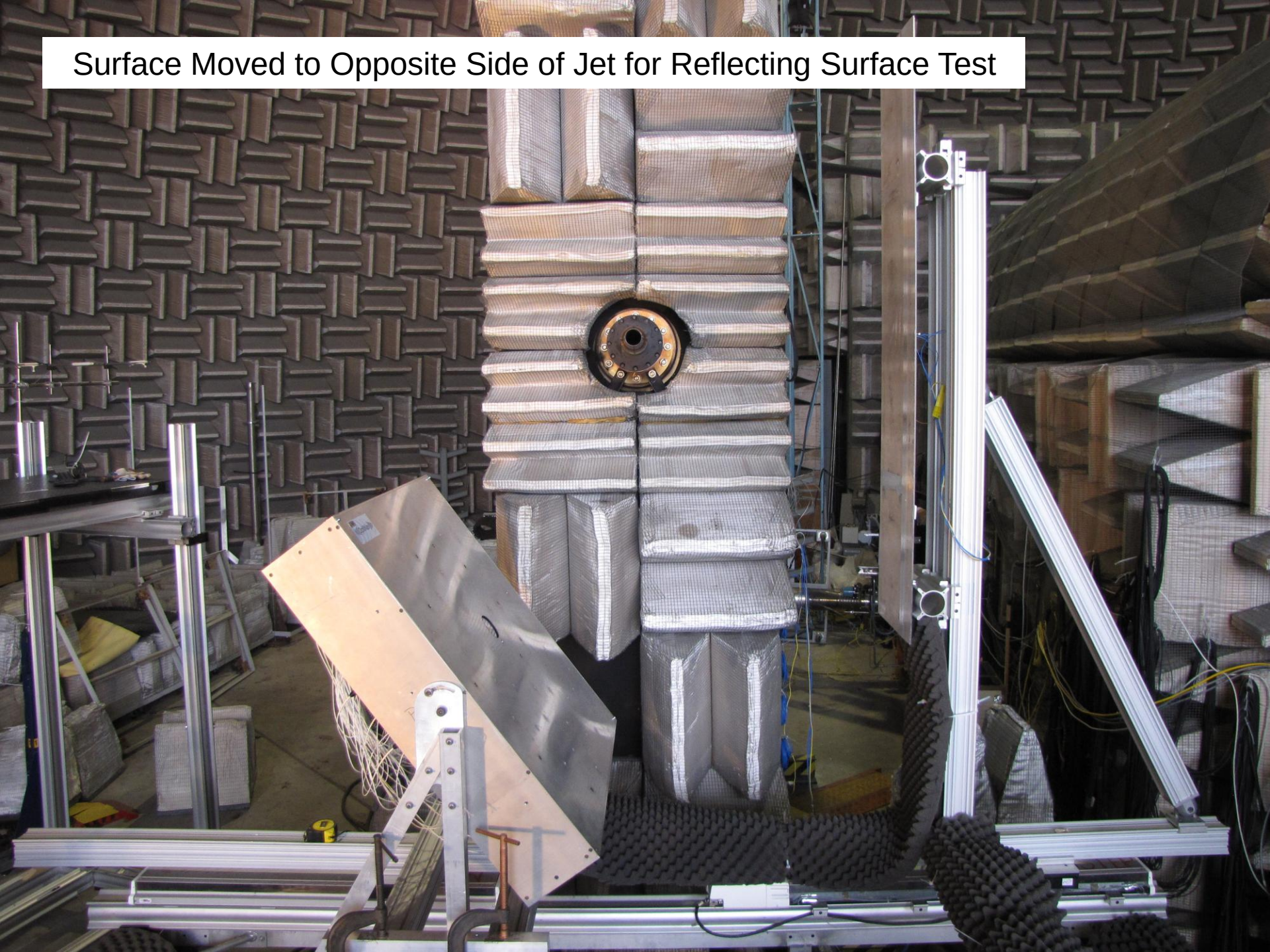


Example Shielding Data

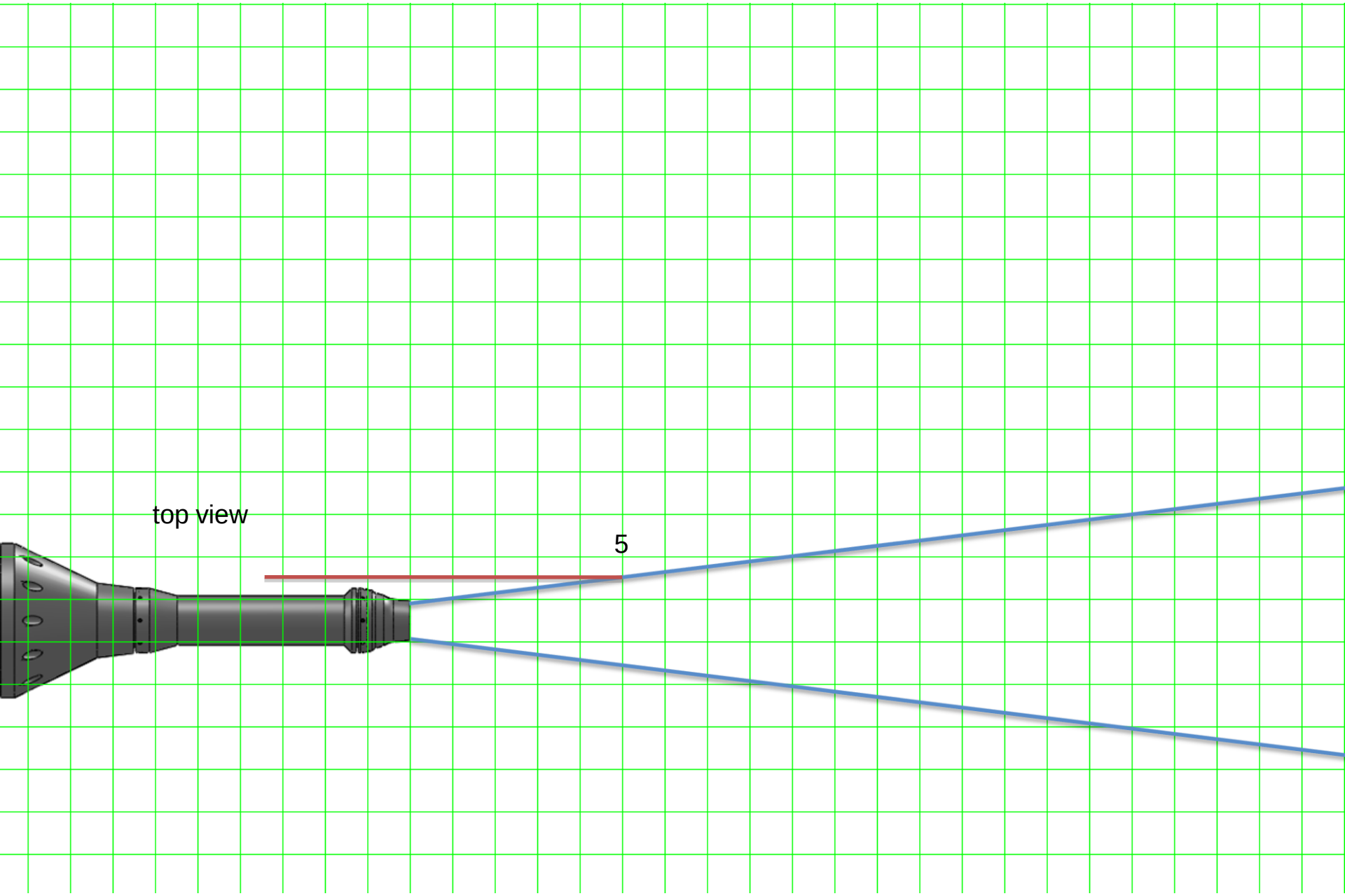
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11617	4.324	0.671	1.41	1.61	Underexpanded



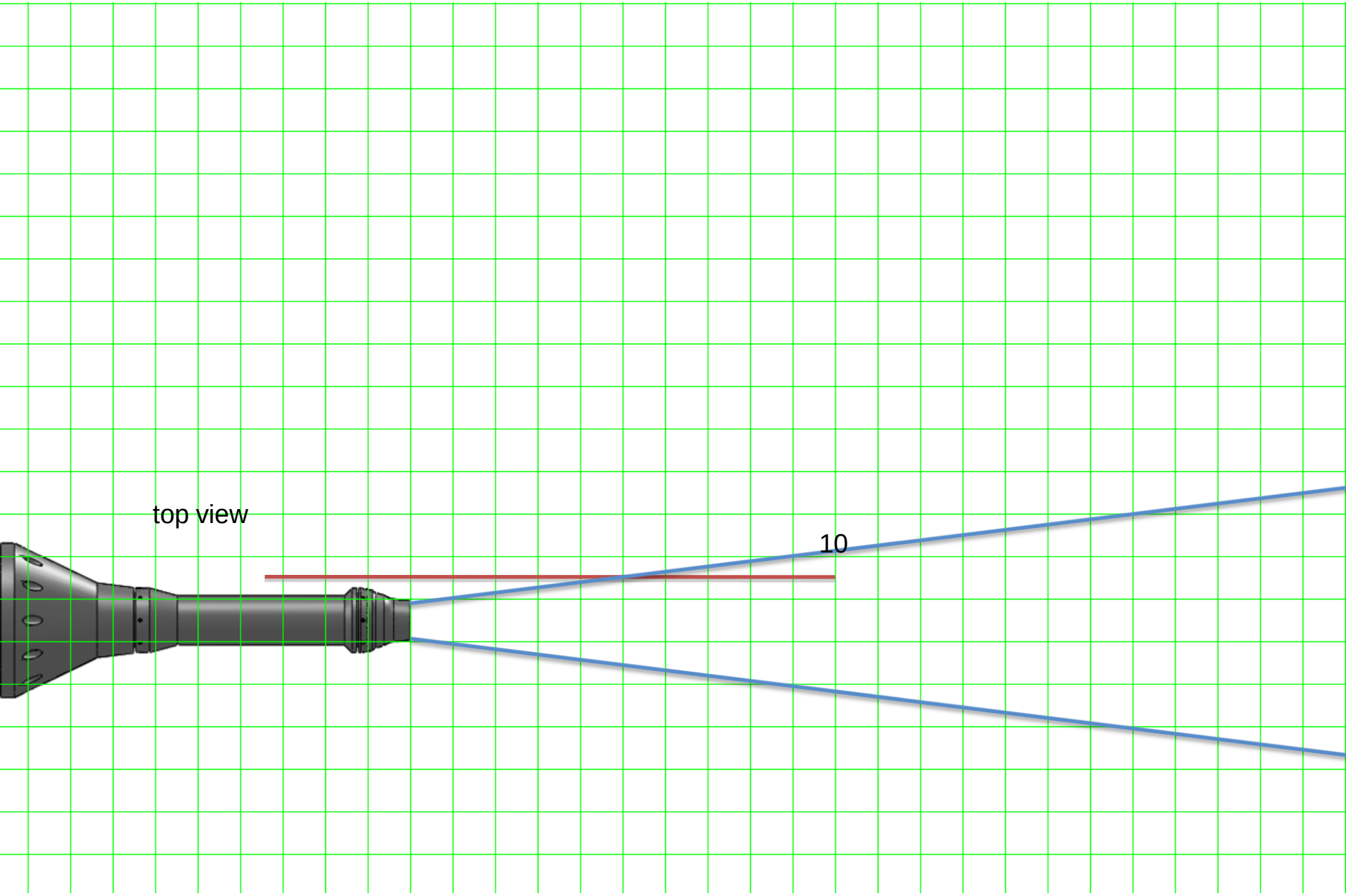



Surface Moved to Opposite Side of Jet for Reflecting Surface Test

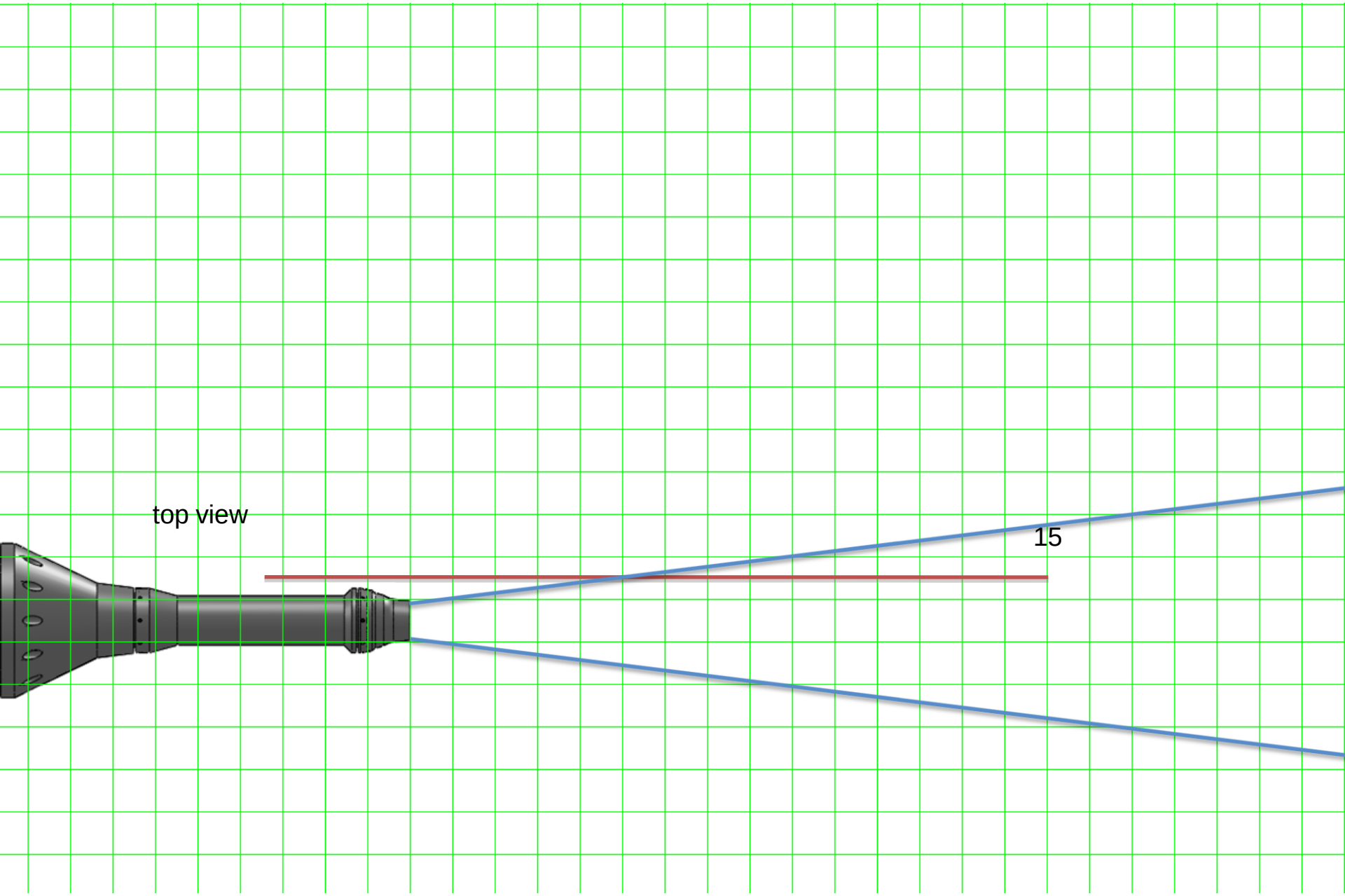
Baseline Round Convergent Nozzle, smc000 Surface TE @ 5 Diams



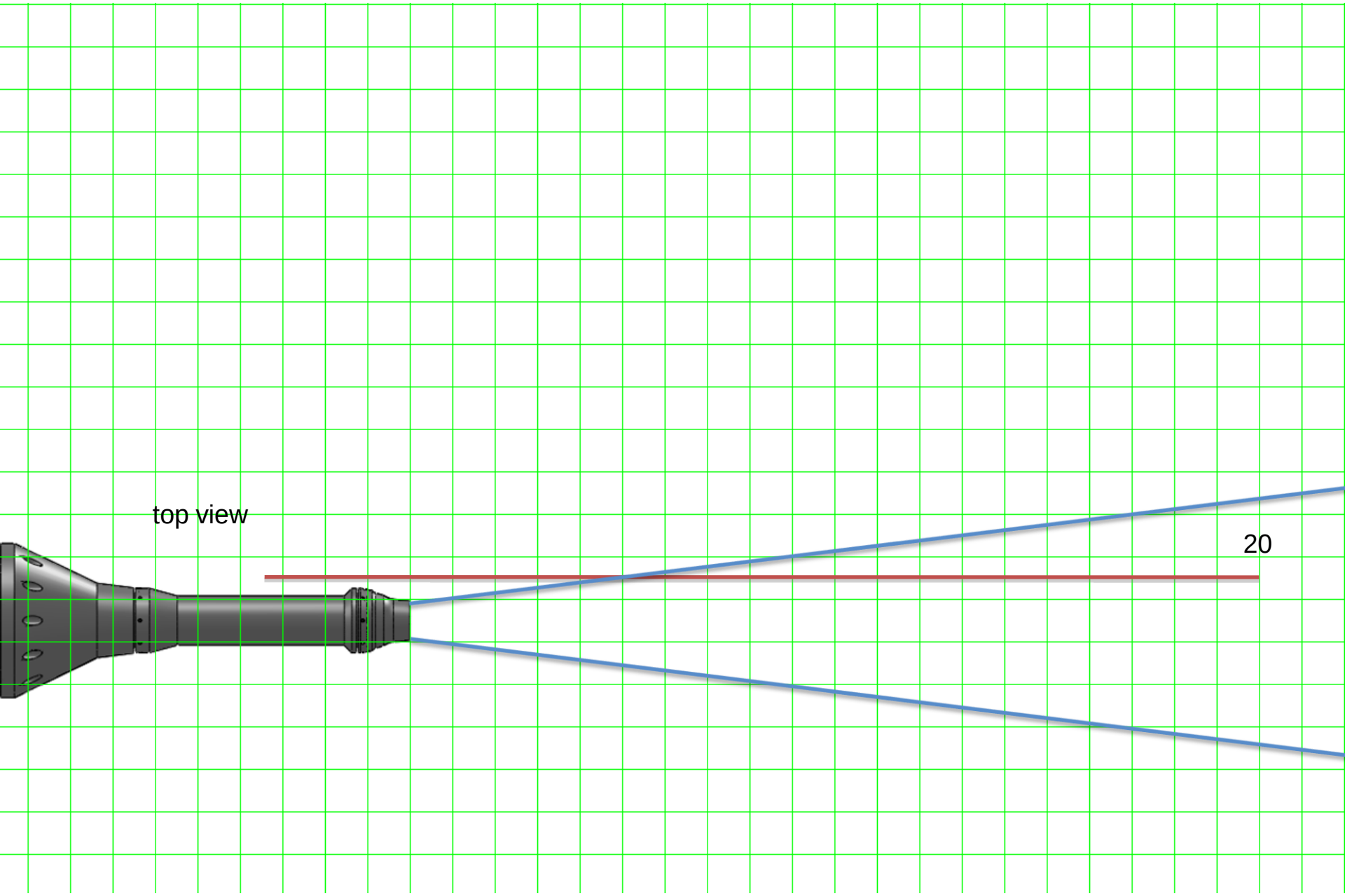
Baseline Round Convergent Nozzle, smc000 Surface TE @ 10 Diams



Baseline Round Convergent Nozzle, smc000 Surface TE @ 15 Diams

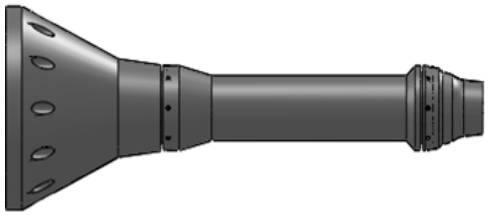


Baseline Round Convergent Nozzle, smc000 Surface TE @ 20 Diams



Reflecting Surface Test

Baseline Round Convergent Nozzle, smc000

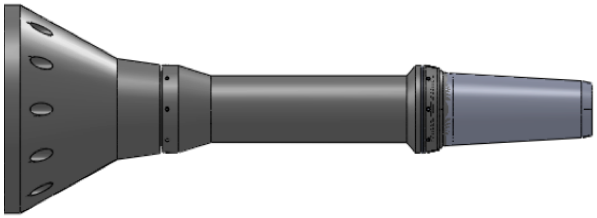


5 Axial X 17 Radial X 3 Set Points

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

Reflecting Surface Test

Convergent Divergent Nozzle, smc016

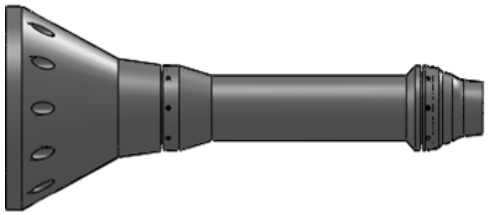


4 Axial X 17 Radial X 3 Set Points

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

Reflecting Surface Test

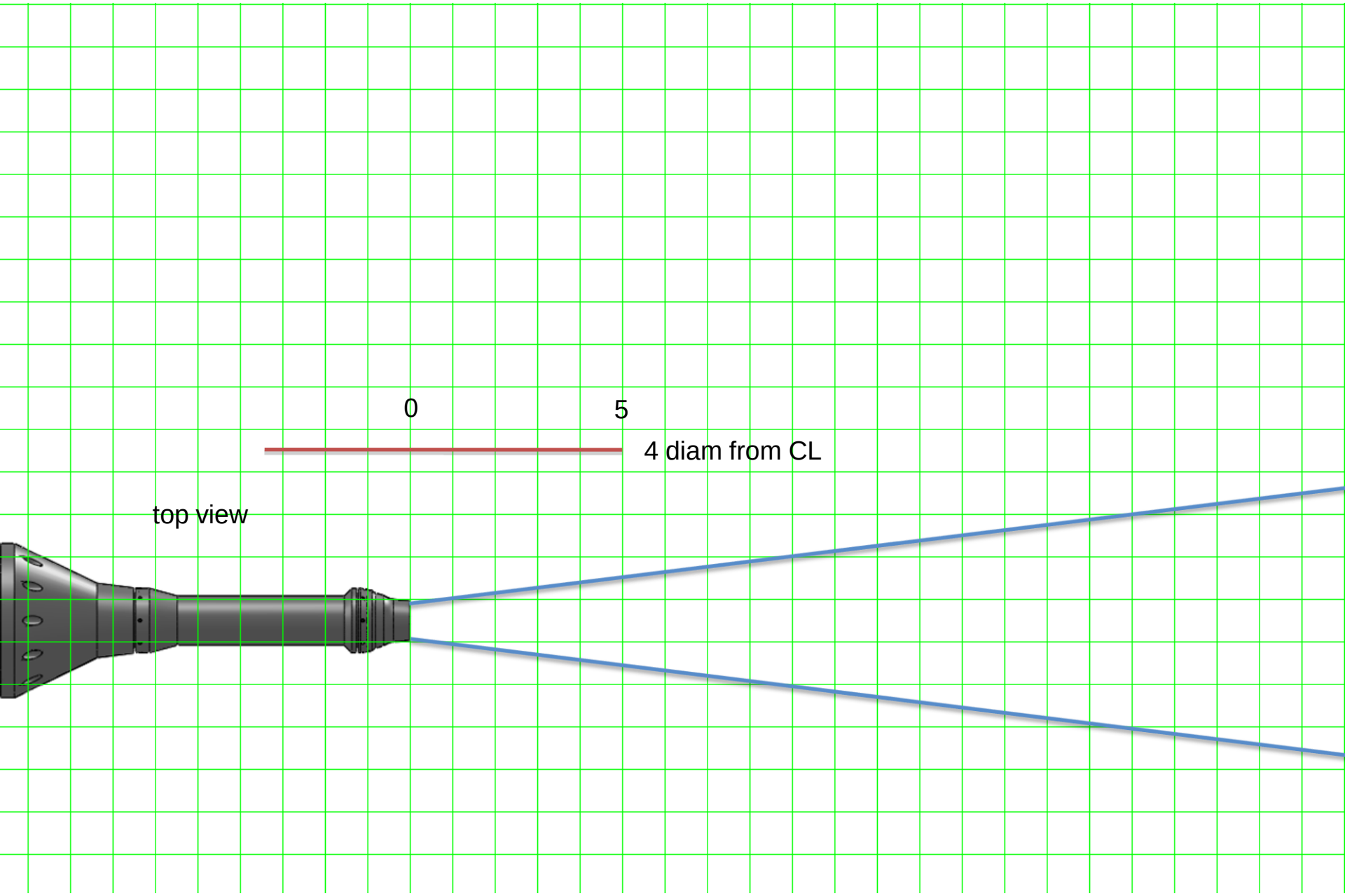
Baseline Round Convergent Nozzle, smc000

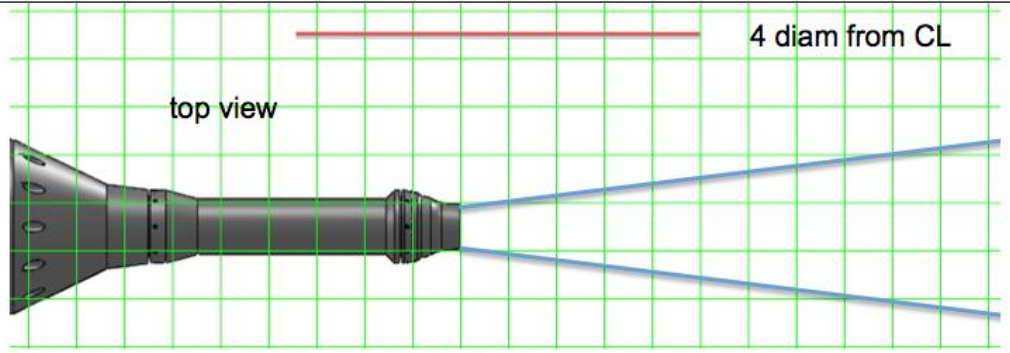


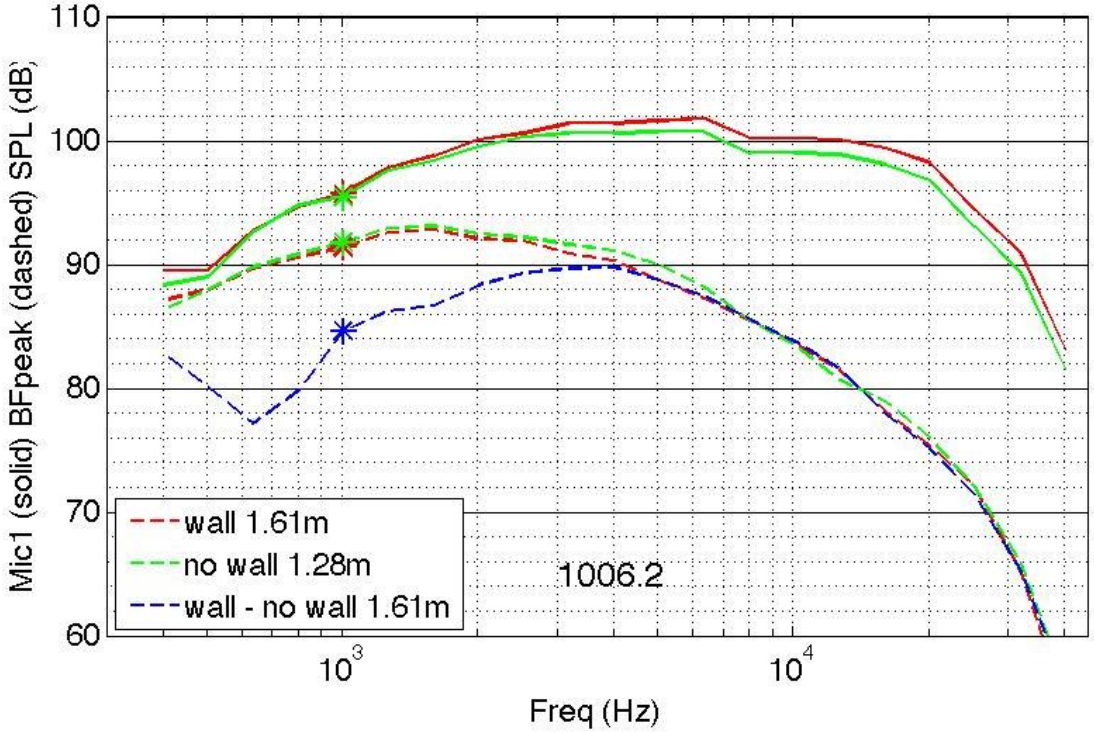
5 Axial X 17 Radial X 3 Set Points

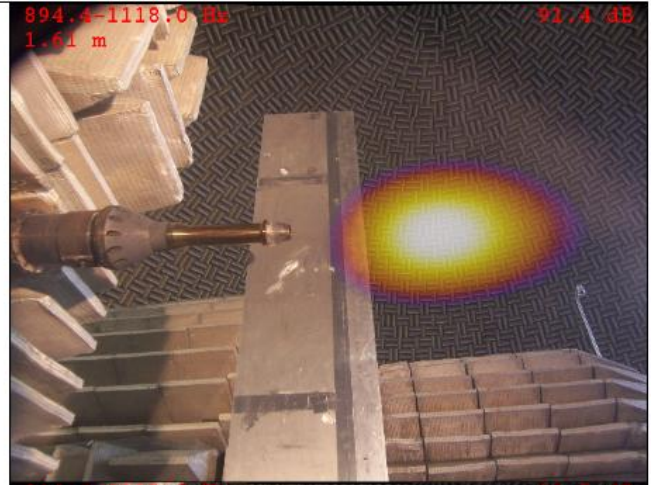
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

Baseline Round Convergent Nozzle, smc000 Surface TE @ 5 Diams

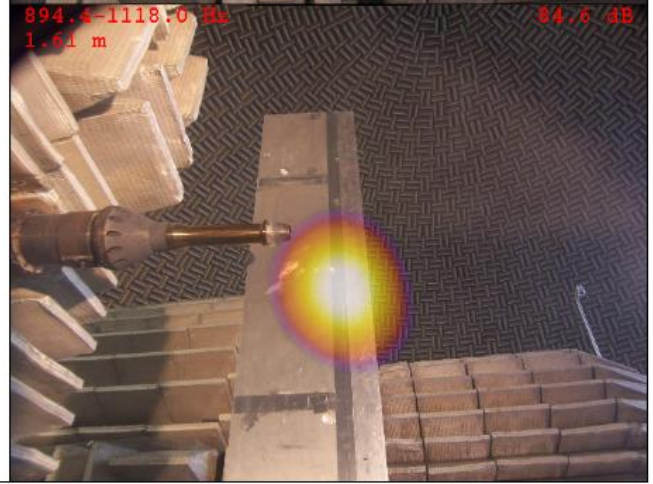



4 diam from CL
top view

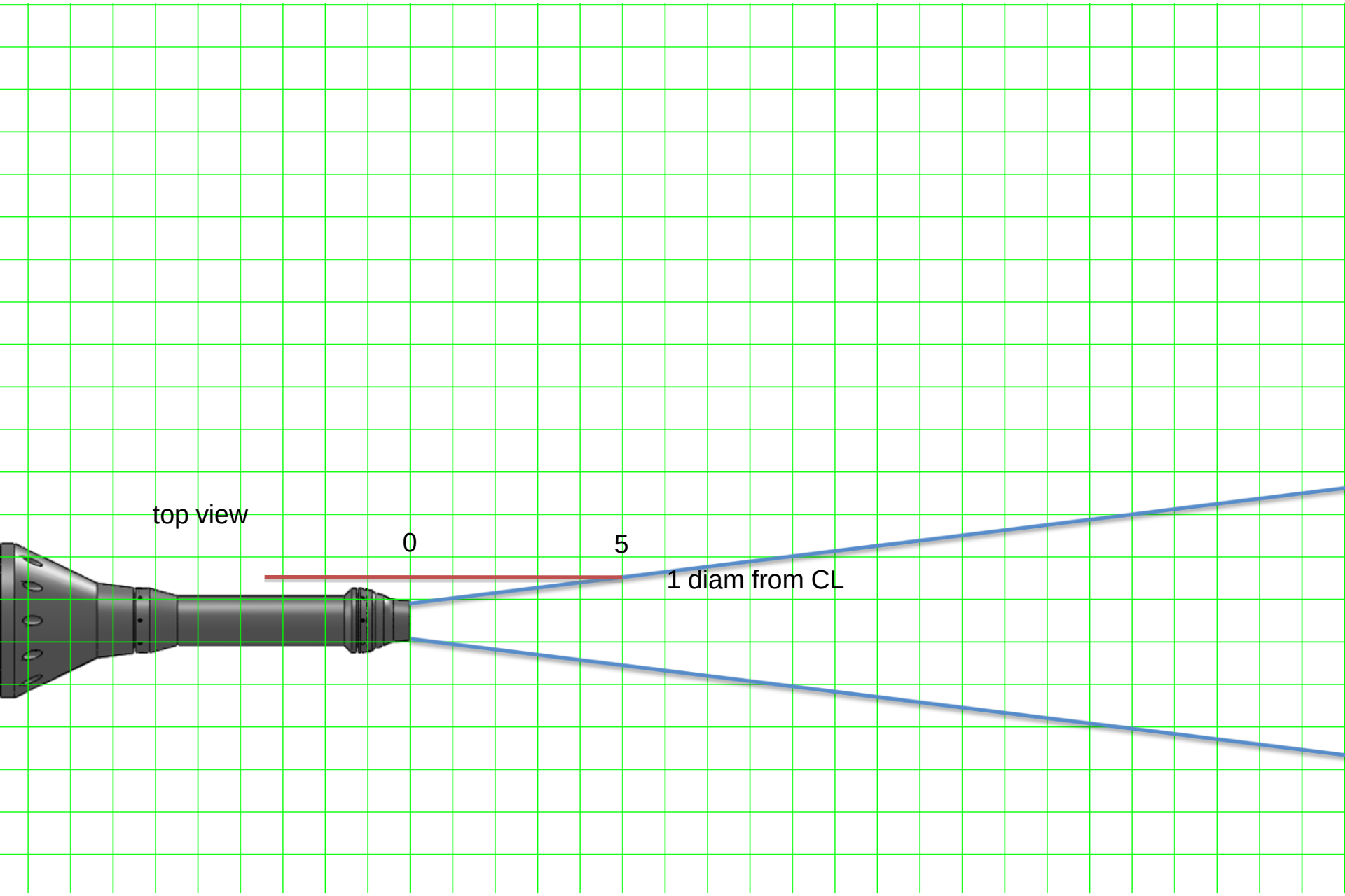

110
100
90
80
70
60
Mic1 (solid) BFpeak (dashed) SPL (dB)
wall 1.61m
no wall 1.28m
wall - no wall 1.61m
1006.2
10^3
10^4
Freq (Hz)

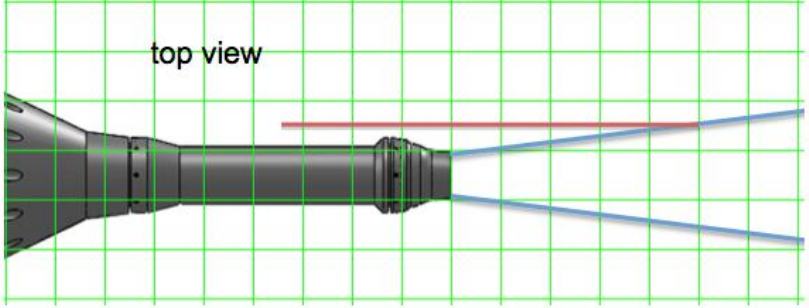

894.4-1118.0 Hz
91.4 dB
1.61 m

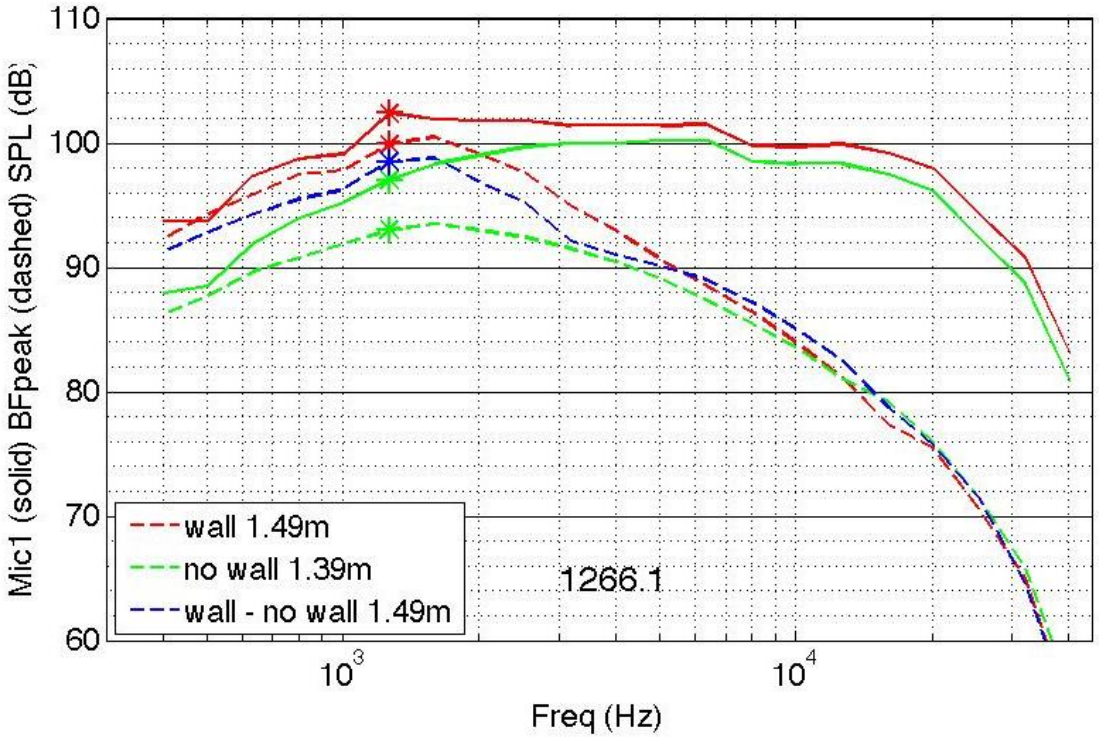

894.4-1118.0 Hz
91.8 dB
1.28 m

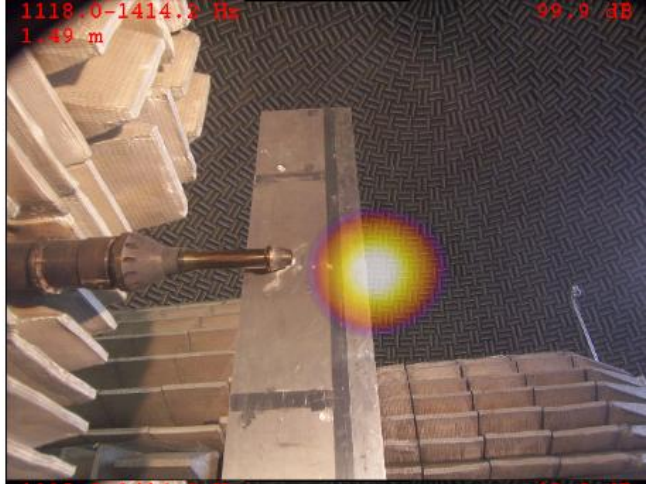

894.4-1118.0 Hz
84.6 dB
1.61 m

Baseline Round Convergent Nozzle, smc000 Surface TE @ 5 Diams

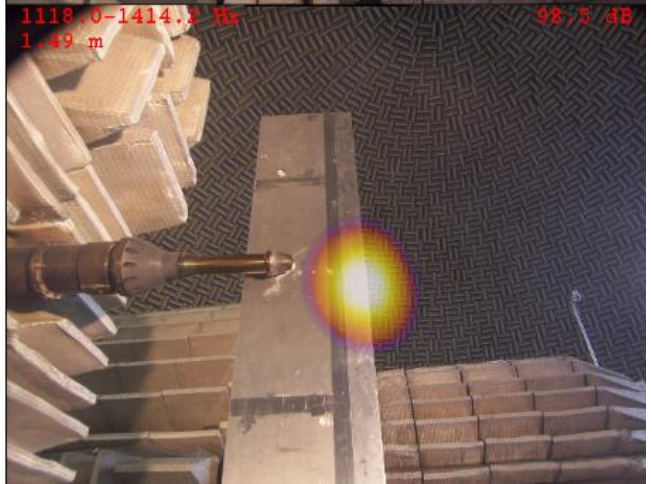


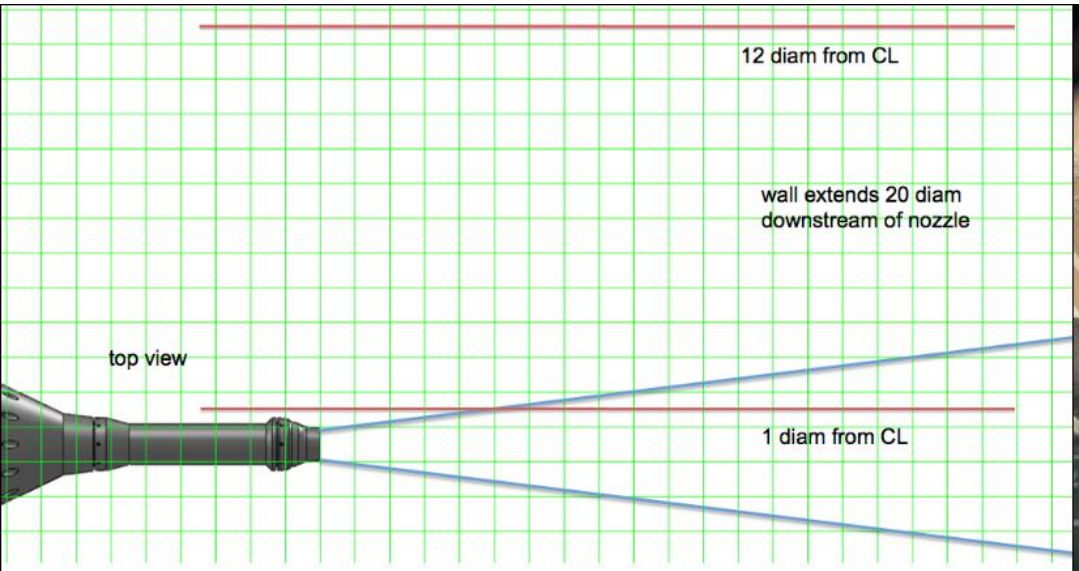

top view

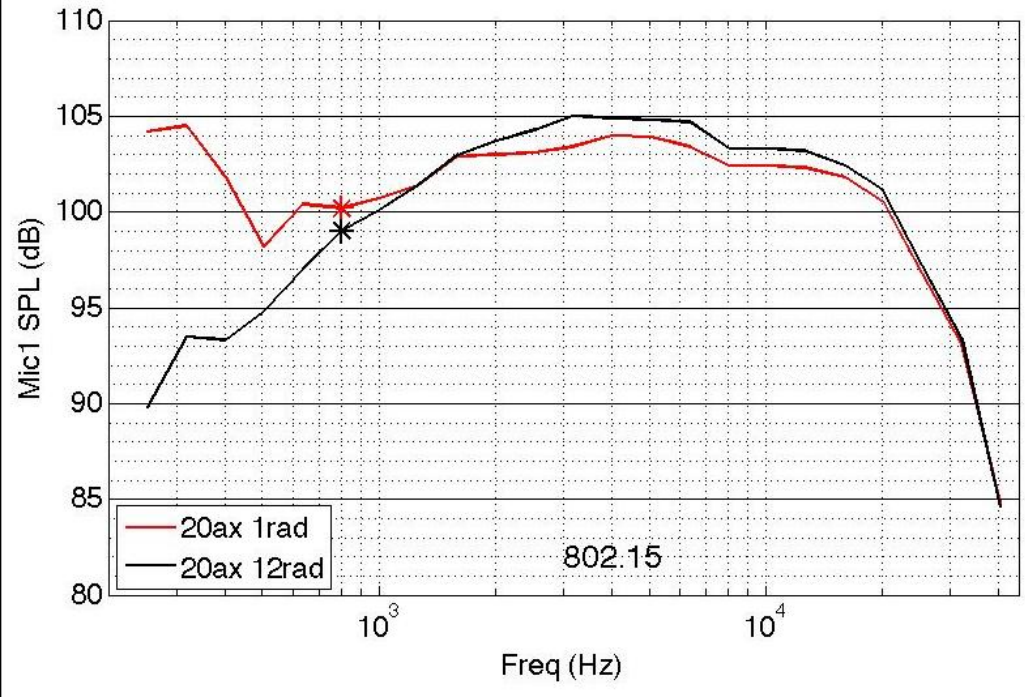

110
100
90
80
70
60
Mic1 (solid) BFpeak (dashed) SPL (dB)
wall 1.49m
no wall 1.39m
wall - no wall 1.49m
1266.1
10^3
10^4
Freq (Hz)

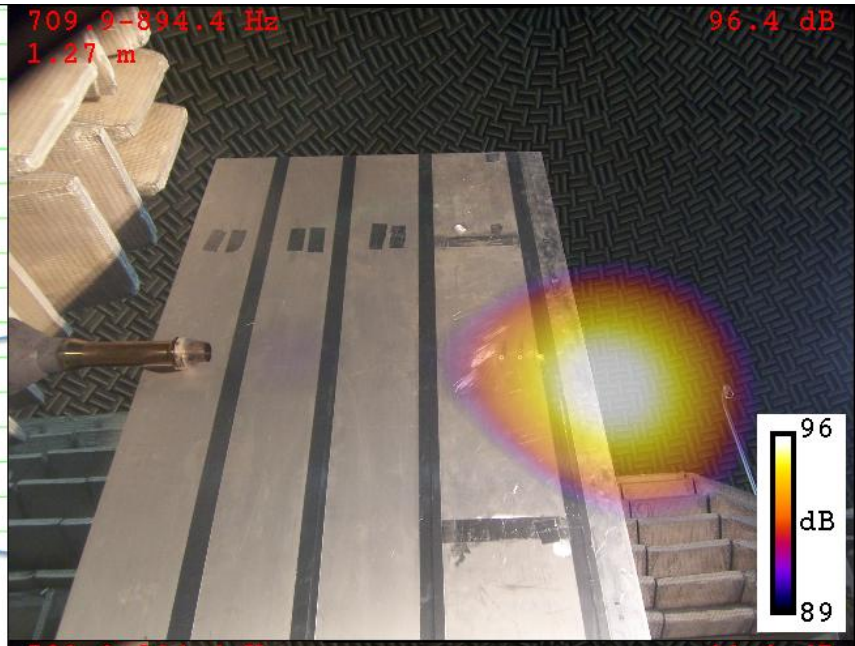

1118.0-1414.2 Hz
99.9 dB
1.49 m

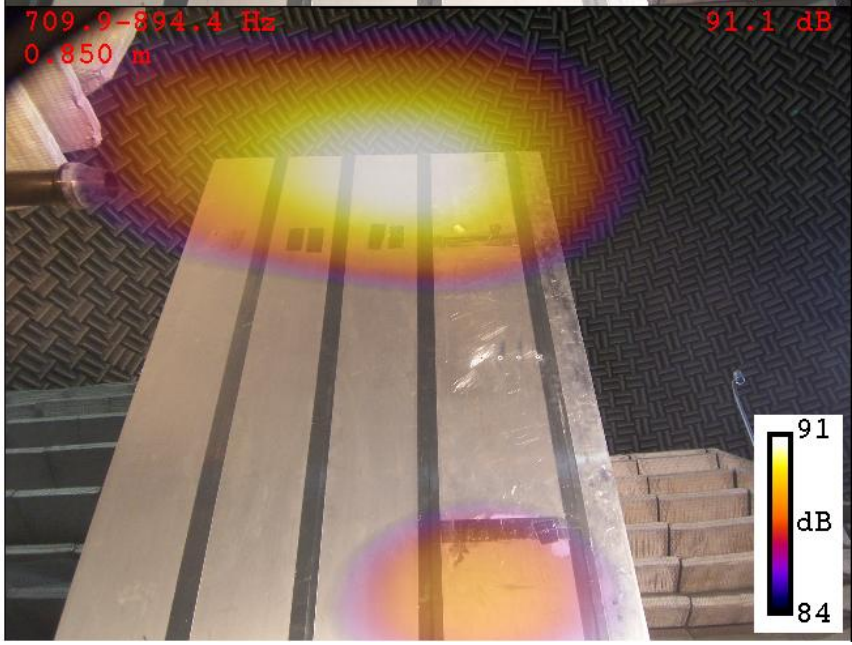

1118.0-1414.2 Hz
93.0 dB
1.39 m


1118.0-1414.2 Hz
98.5 dB
1.49 m


12 diam from CL
wall extends 20 diam
downstream of nozzle
top view
1 diam from CL


110
105
100
95
90
85
80
Mic1 SPL (dB)
20ax 1rad
20ax 12rad
802.15
10^3
10^4
Freq (Hz)

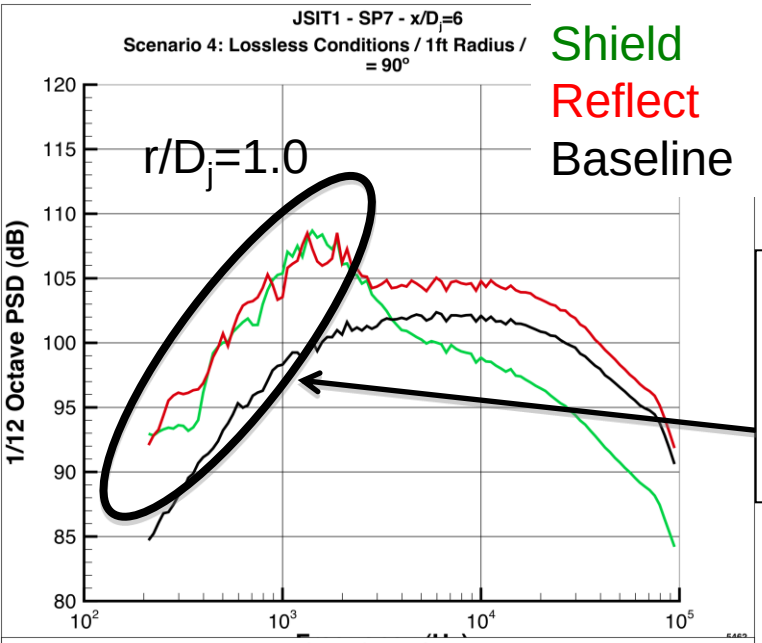

709.9-894.4 Hz
1.27 m
96.4 dB
96
dB
89

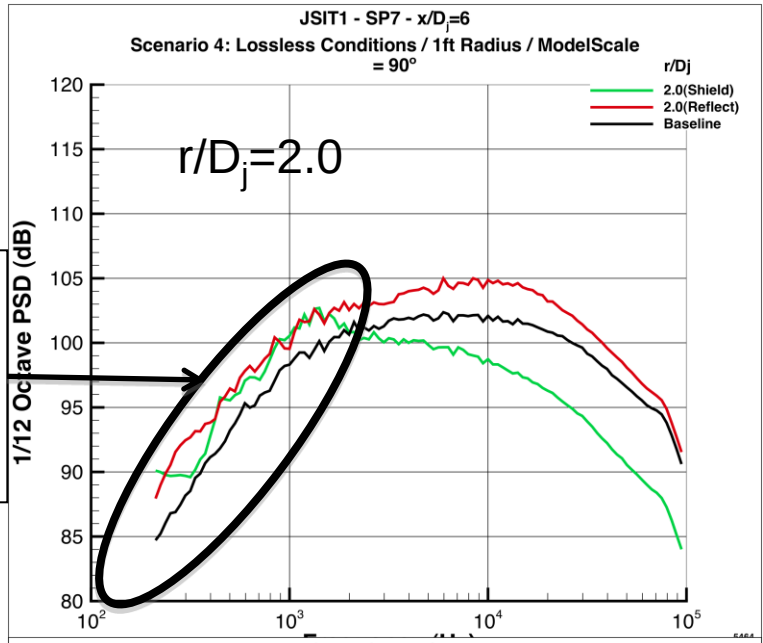

709.9-894.4 Hz
0.850 m
91.1 dB
91
dB
84

Trailing Edge Source

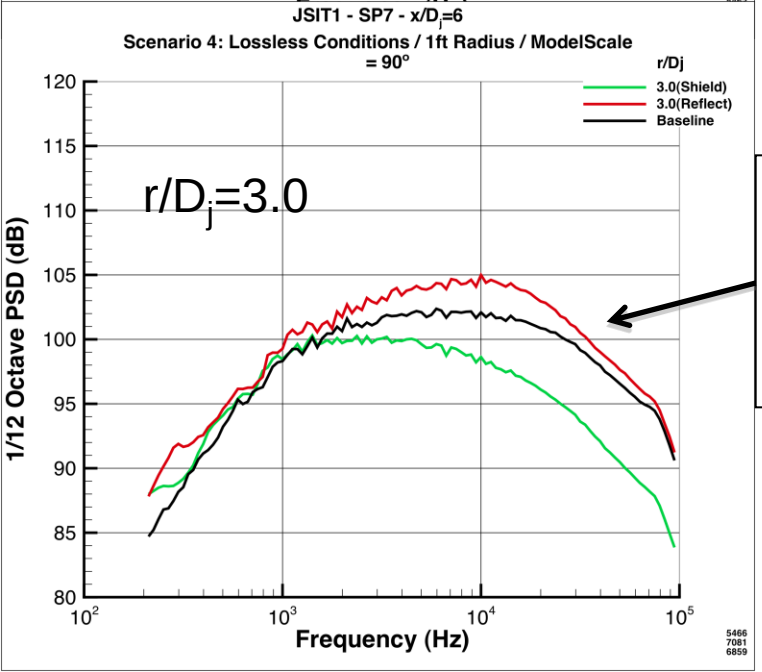
Far-Field Acoustic Data – x/D_j=6.0, θ=90°

Shield
Reflect
Baseline

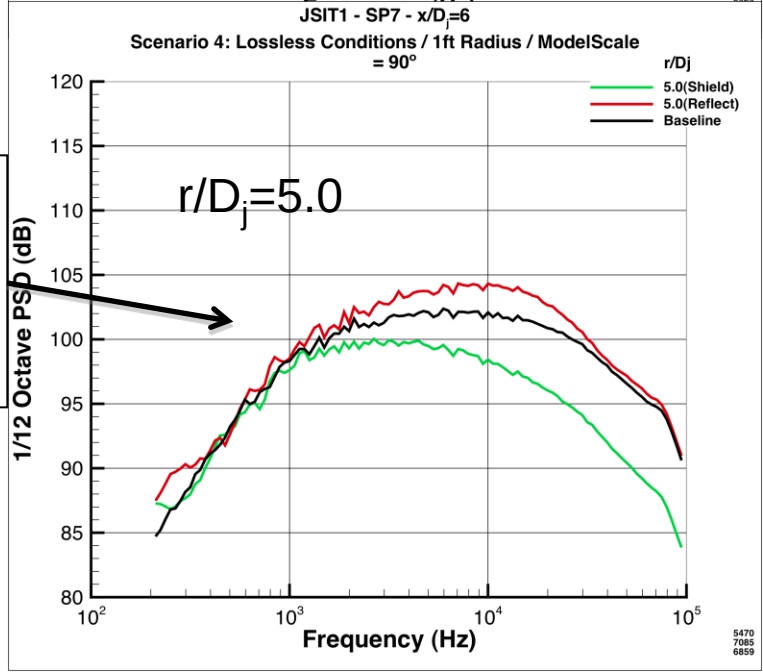


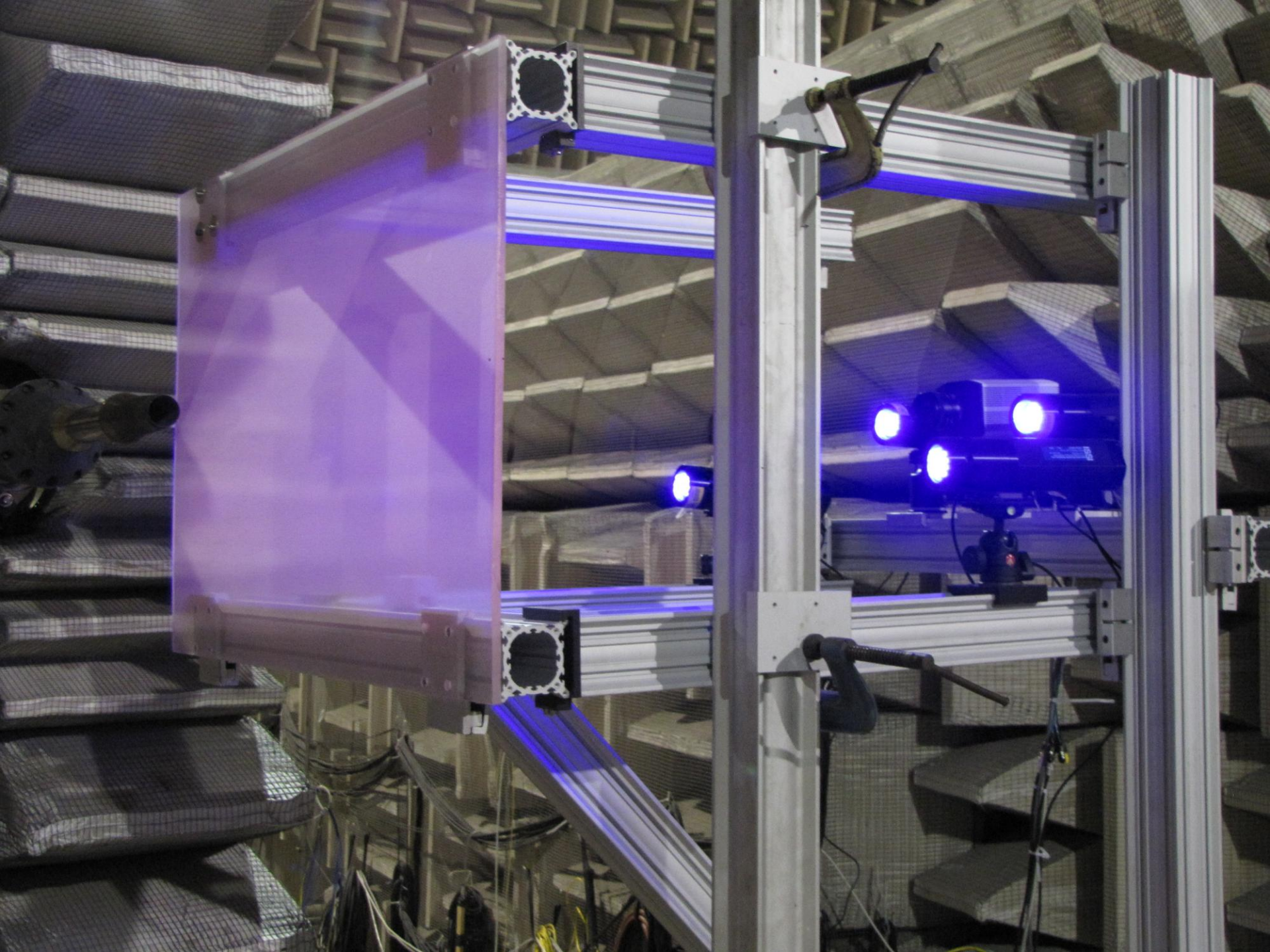


Trailing edge noise – same for shield and reflect configurations



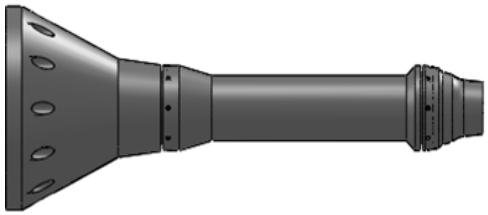
Surface out of the jet flow – no trailing edge noise





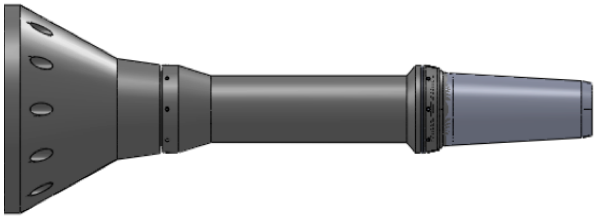
PSP Data

Baseline Round Convergent Nozzle, smc000



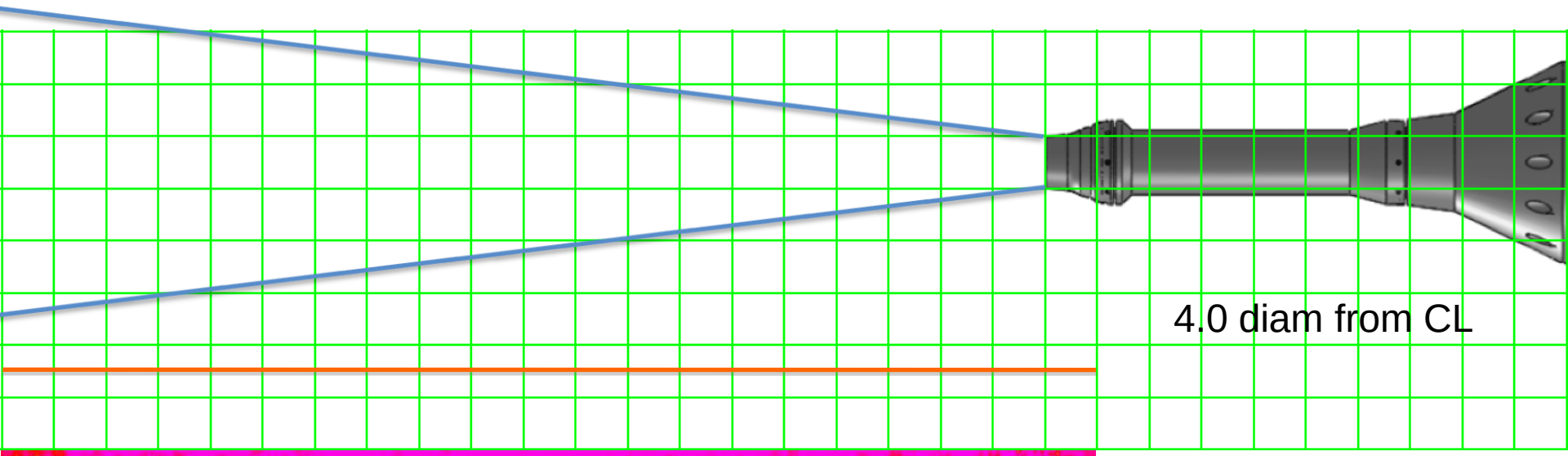
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

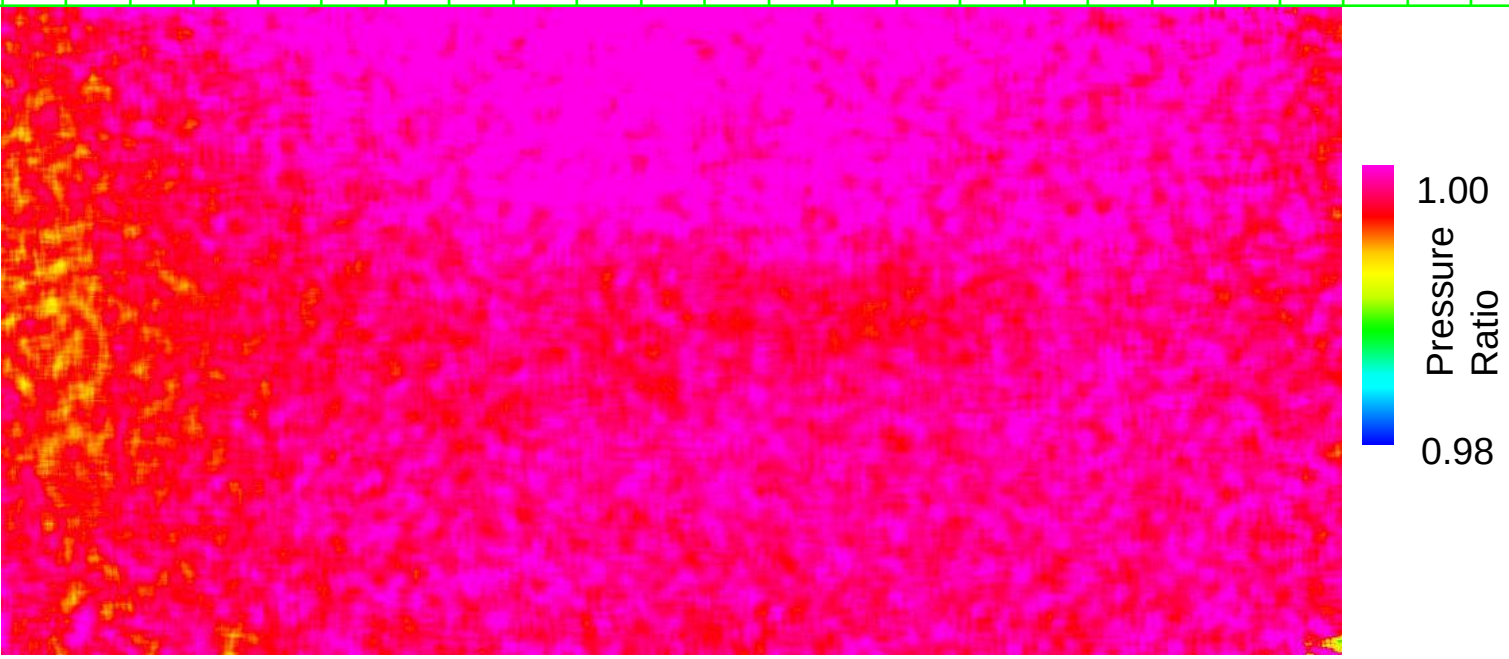
Convergent Divergent Nozzle, smc016



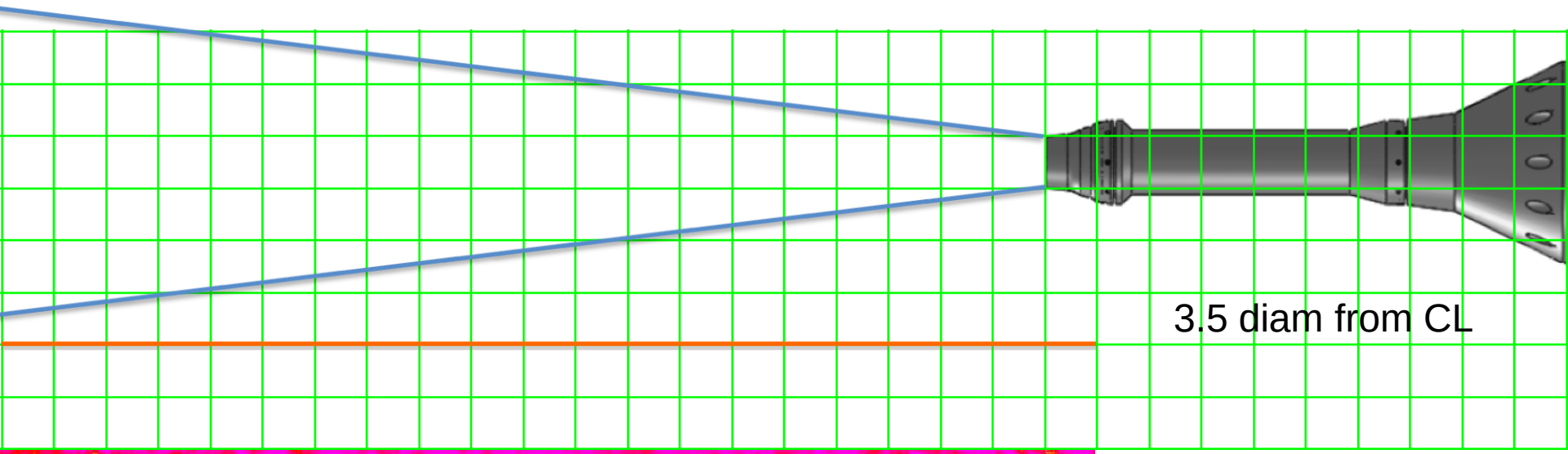
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

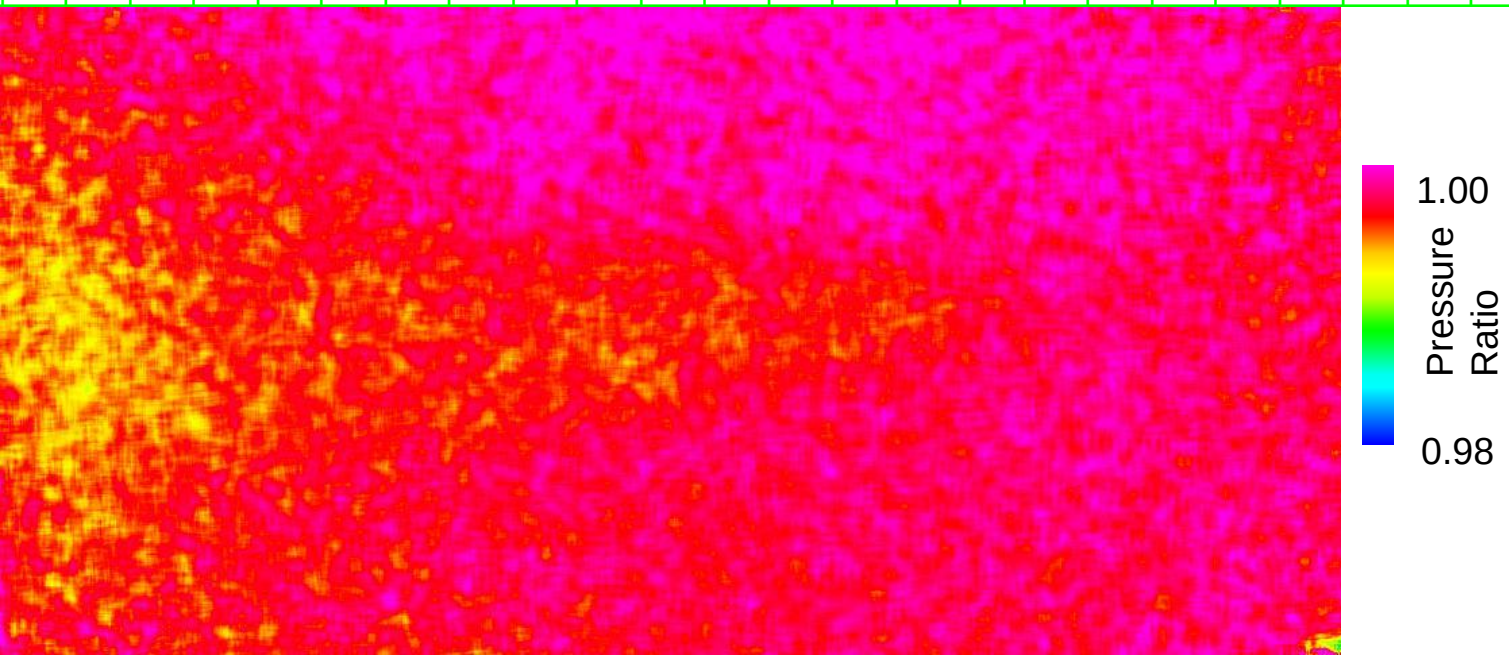
SMC000 RC Nozzle Set Point 7 M_a=0.9



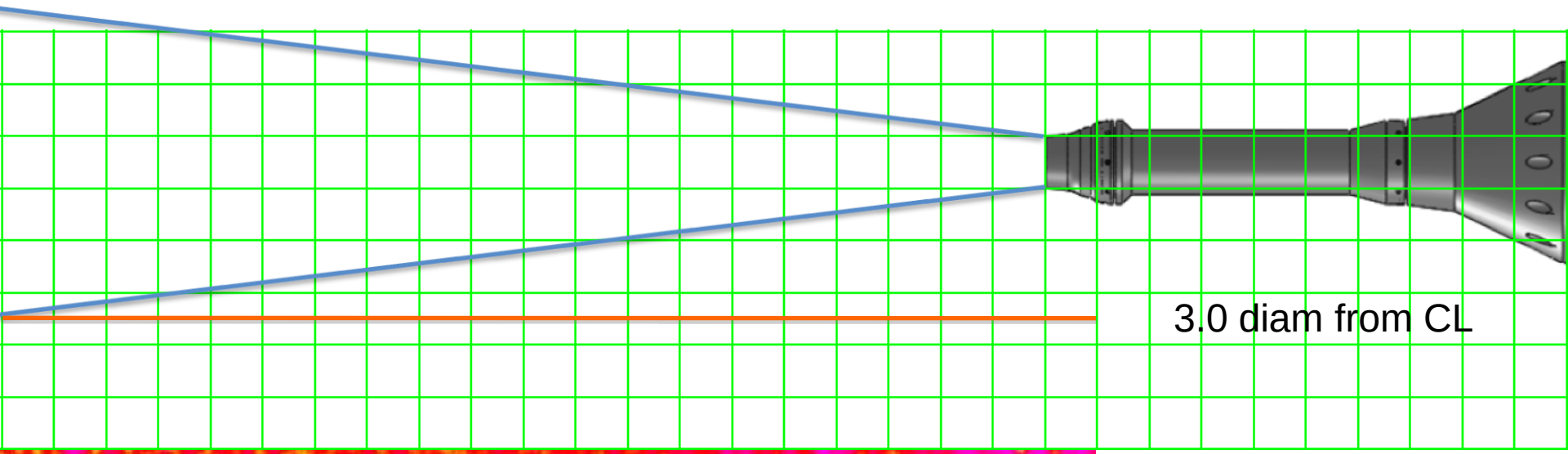


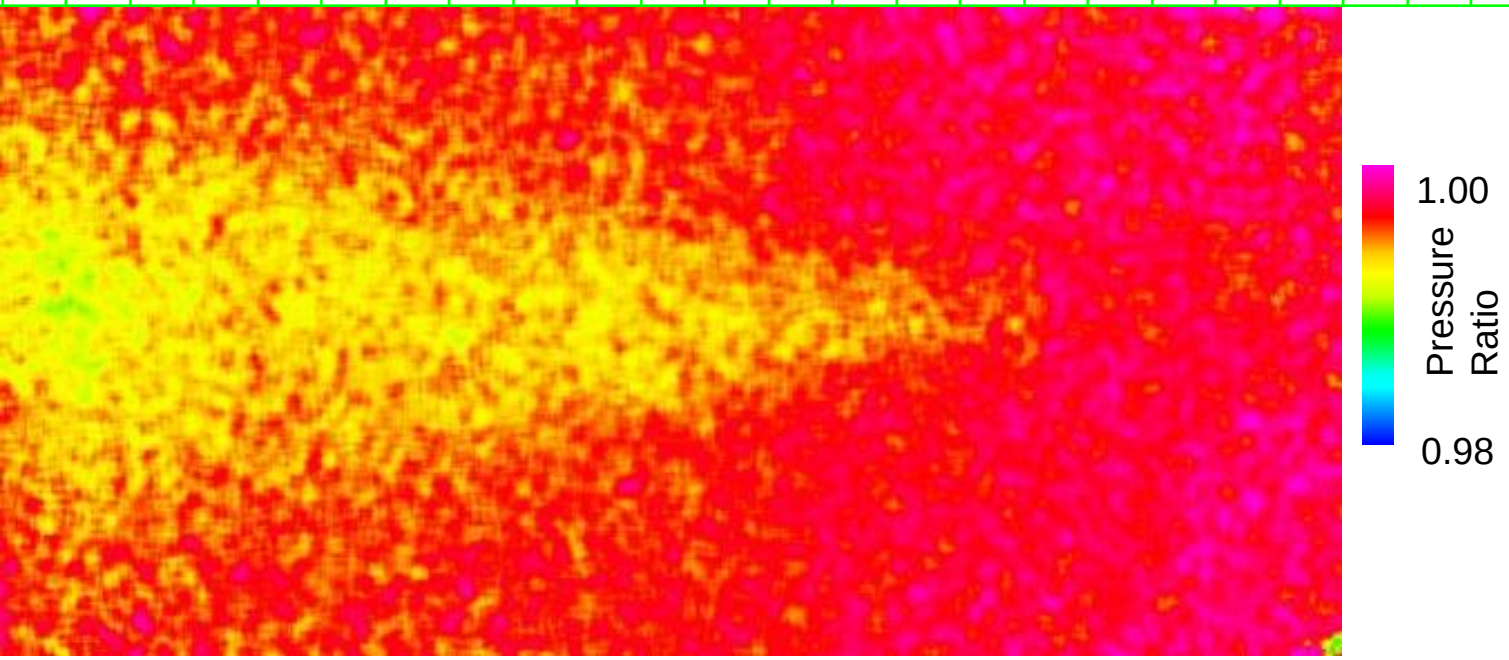
SMC000 RC Nozzle Set Point 7 M_a=0.9



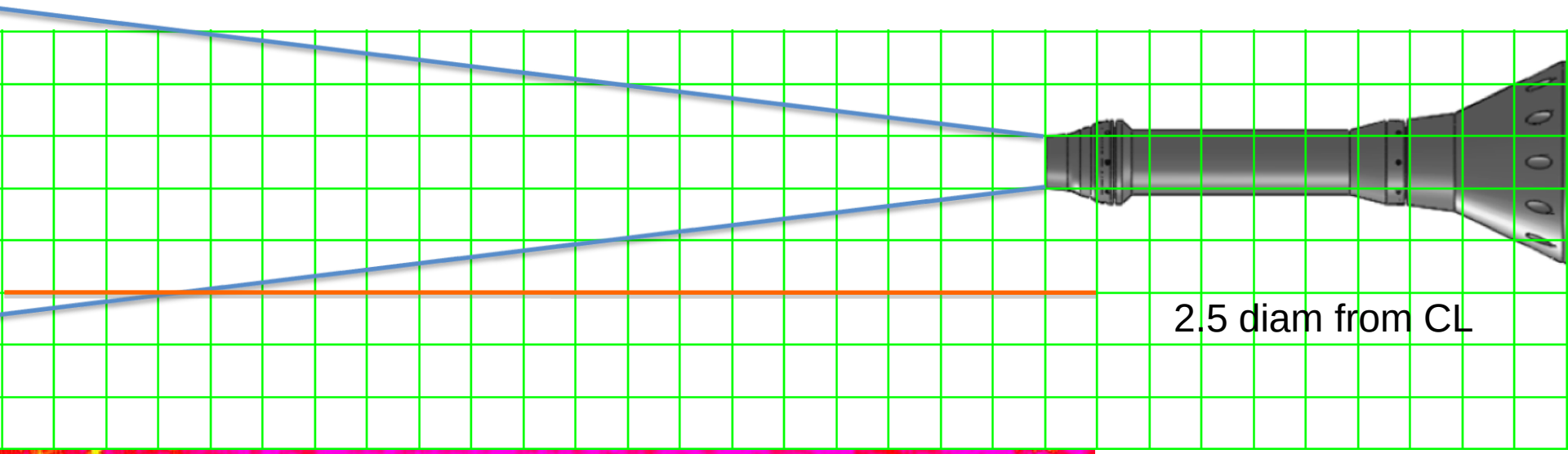


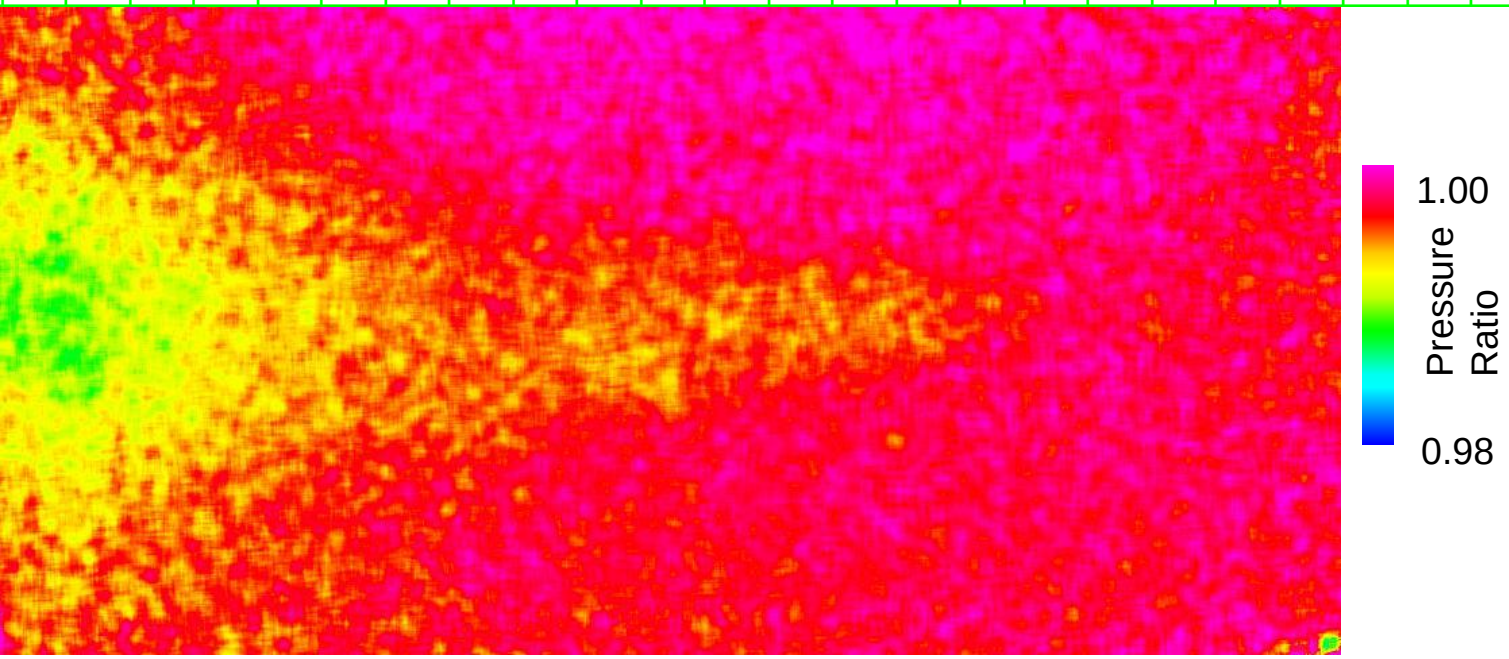
SMC000 RC Nozzle Set Point 7 M_a=0.9



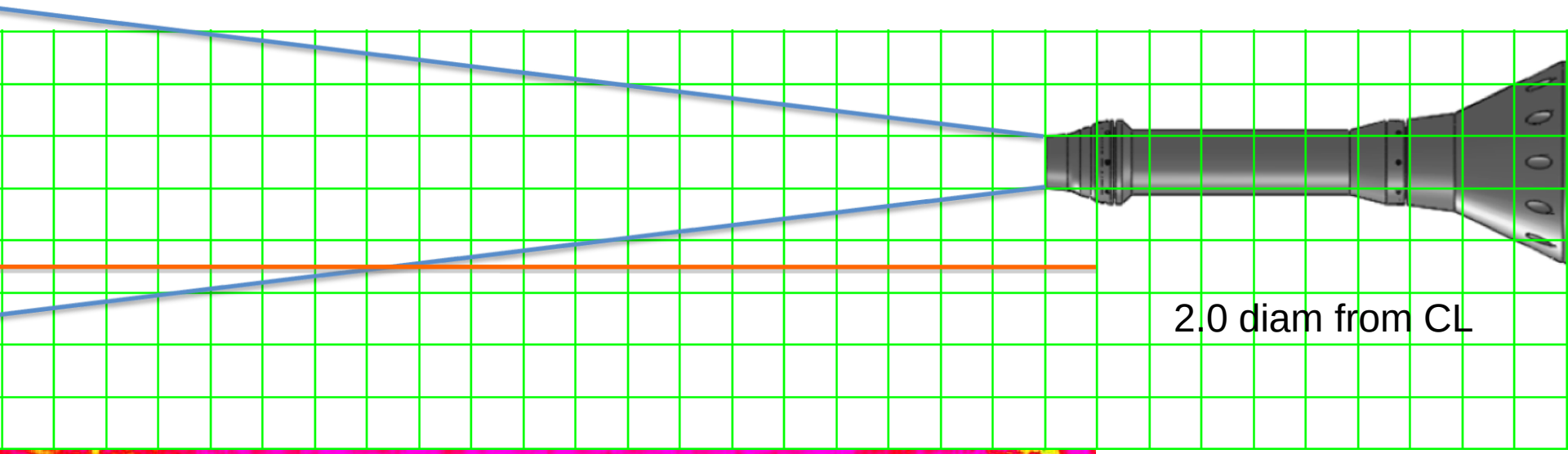


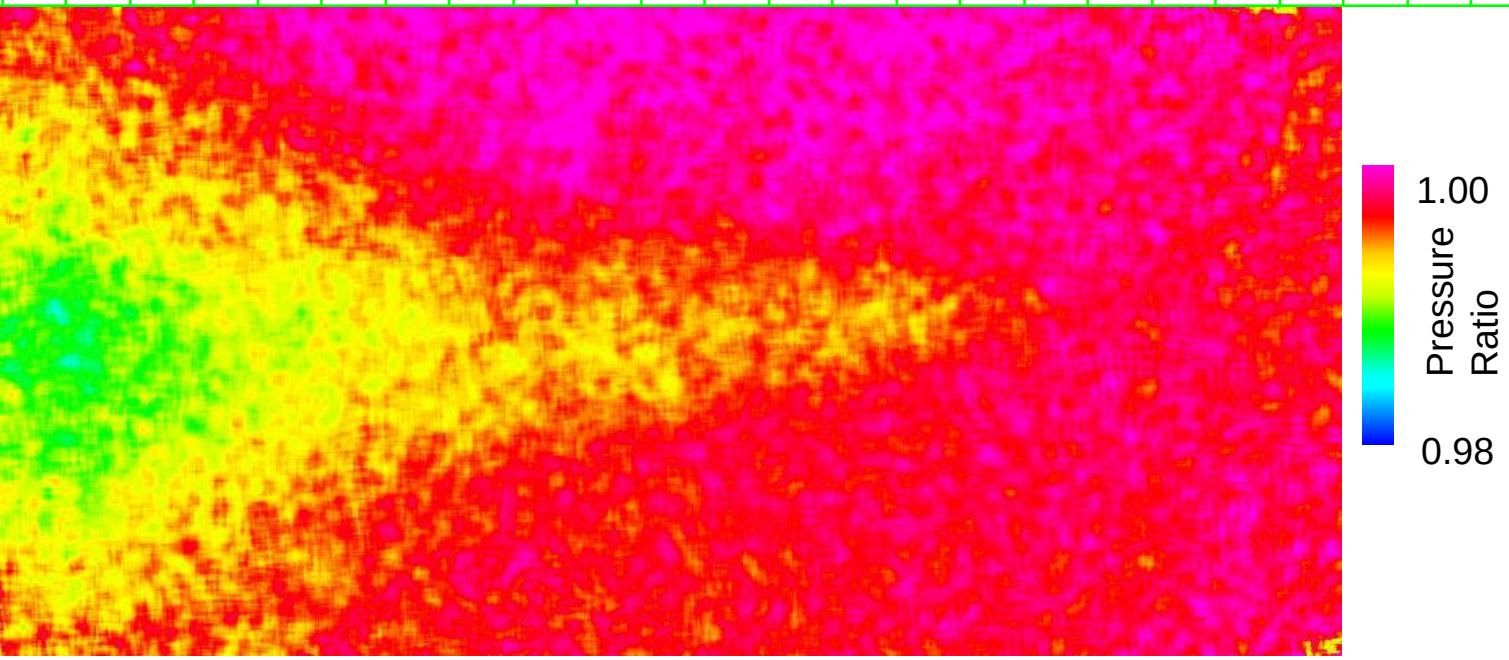
SMC000 RC Nozzle Set Point 7 M_a=0.9



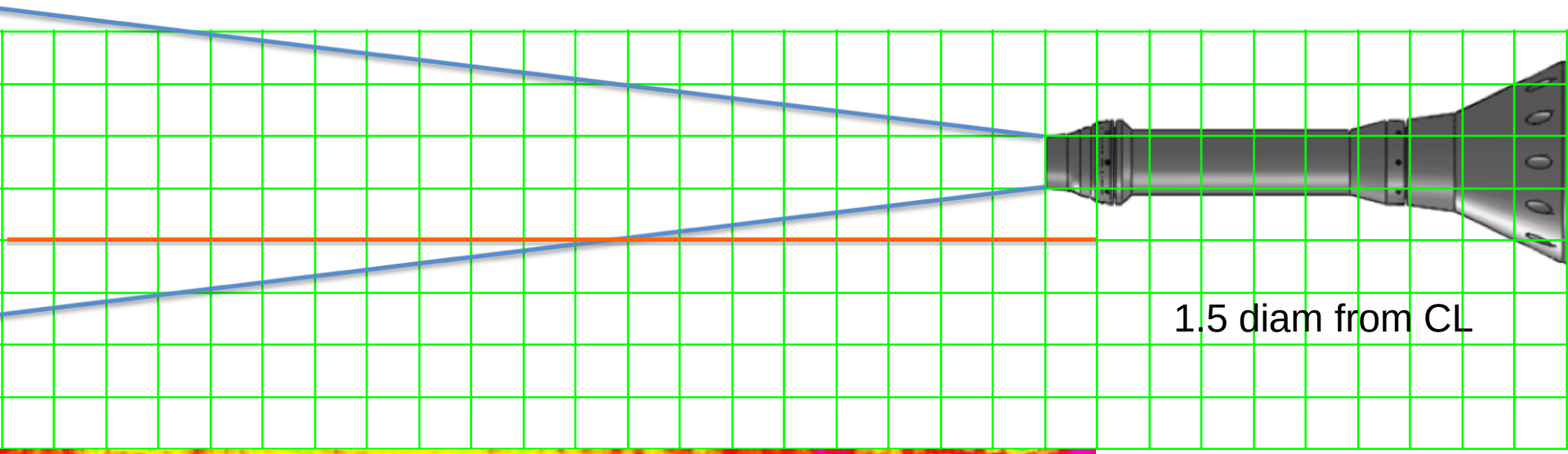


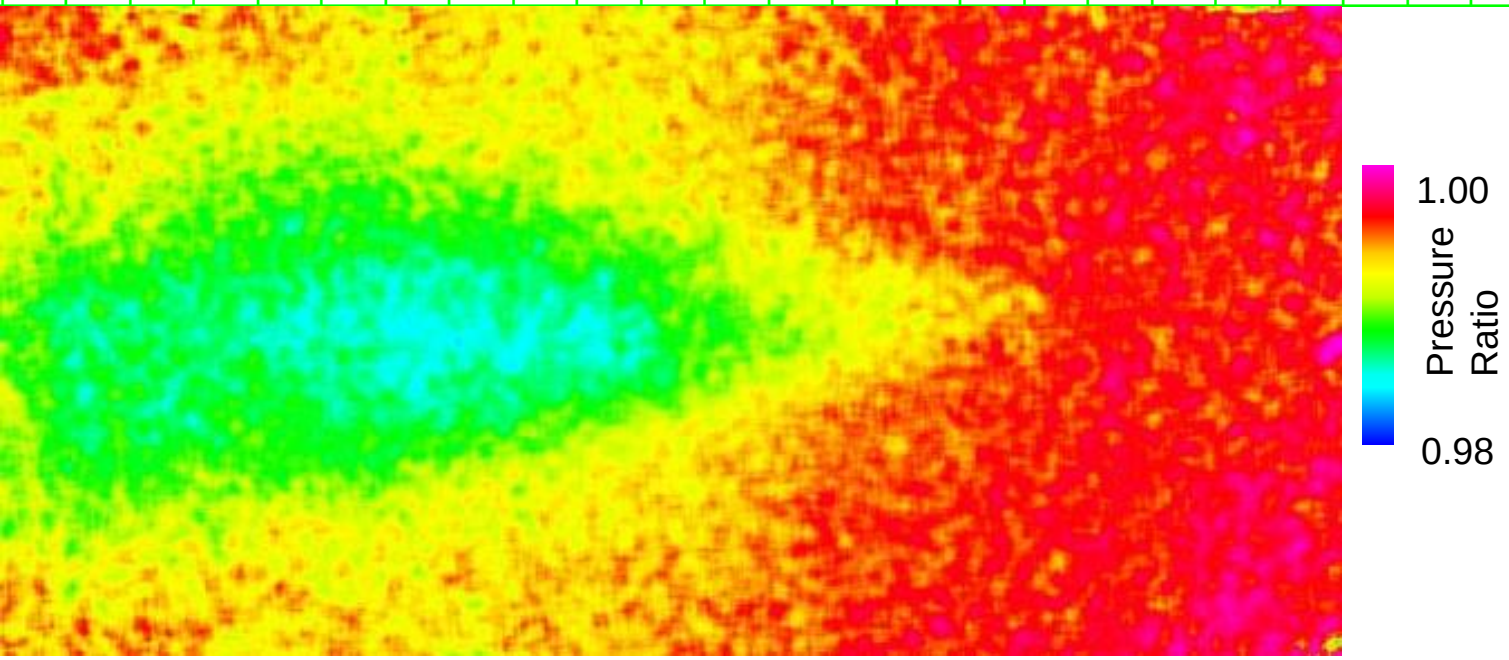
SMC000 RC Nozzle Set Point 7 M_a=0.9



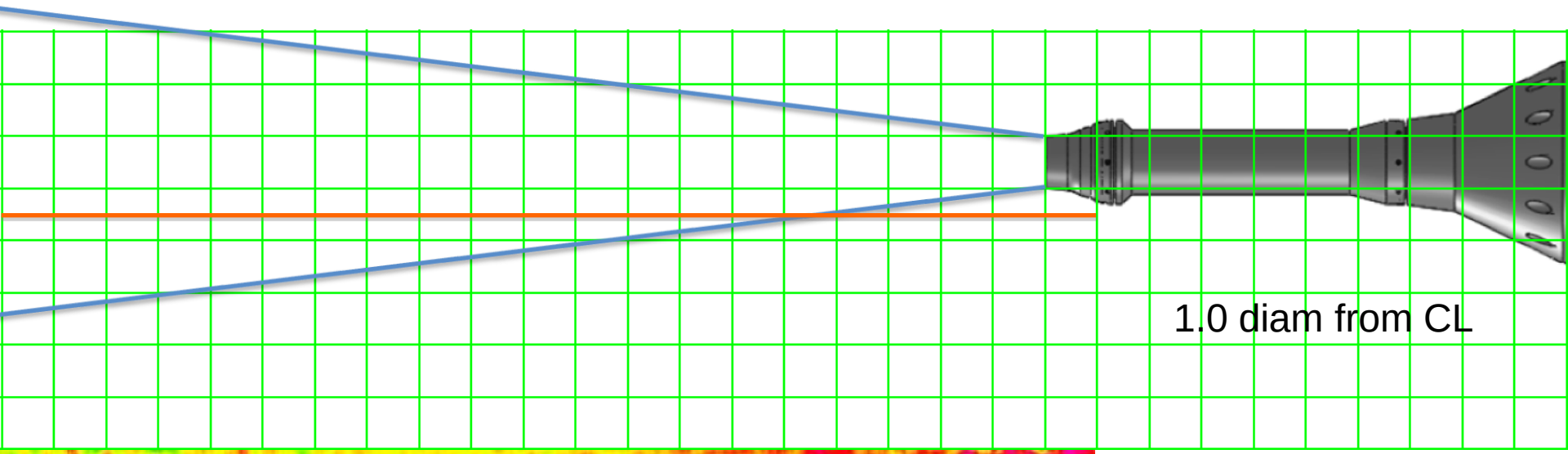


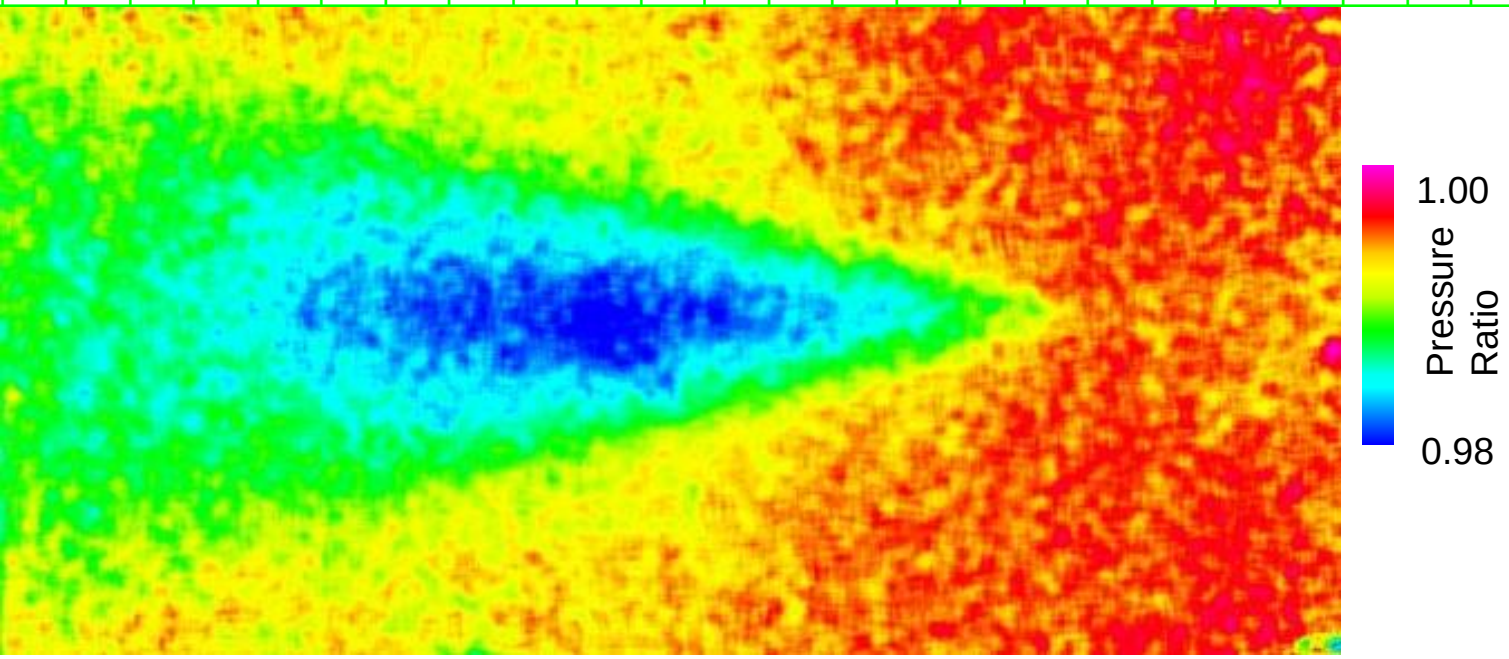
SMC000 RC Nozzle Set Point 7 M_a=0.9



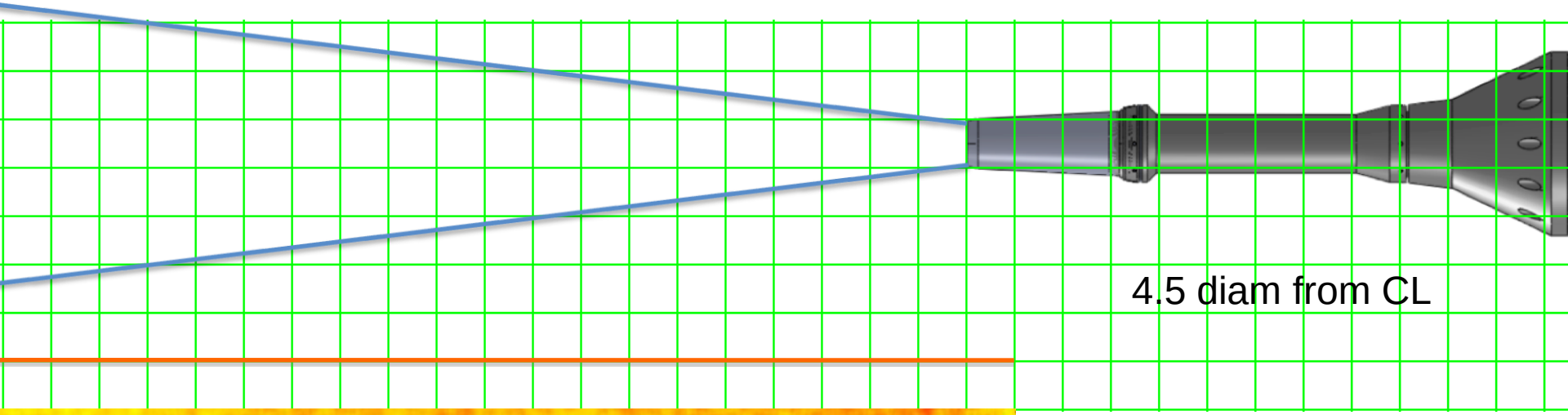


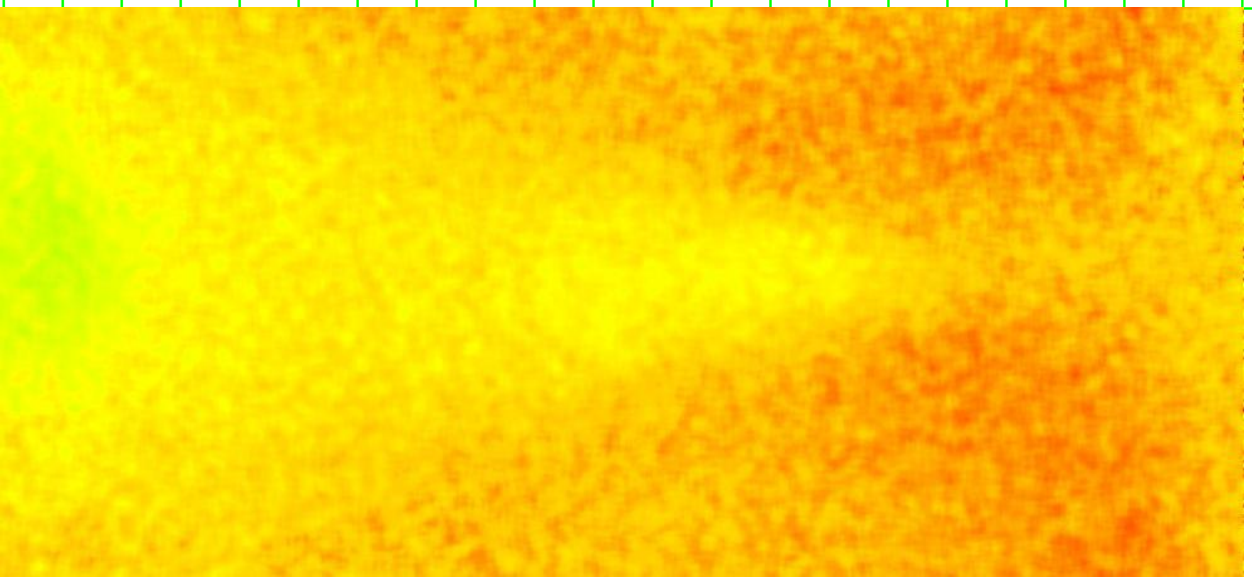
SMC000 RC Nozzle Set Point 7 M_a=0.9

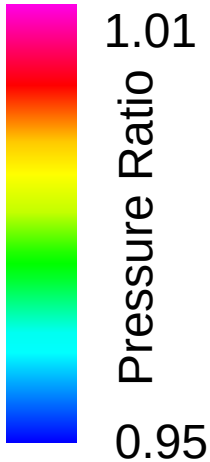




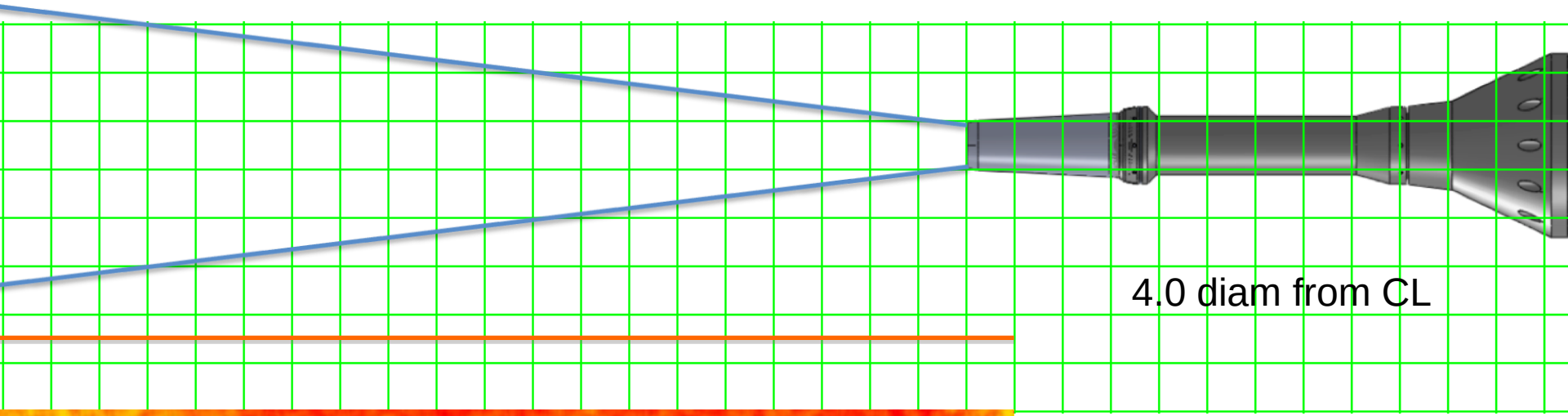
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5

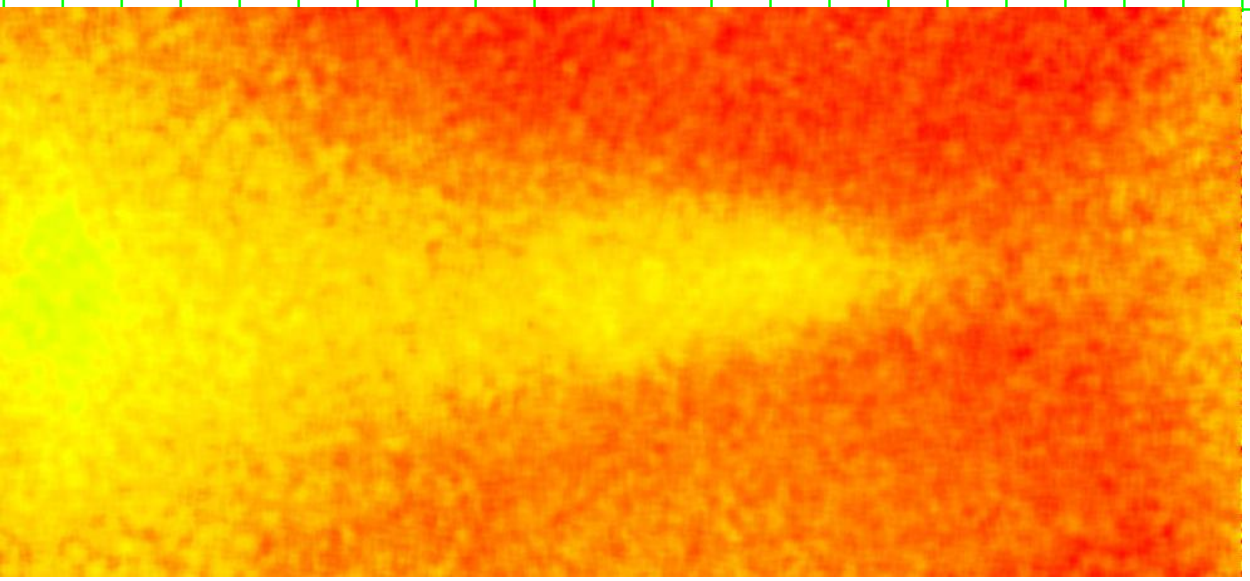


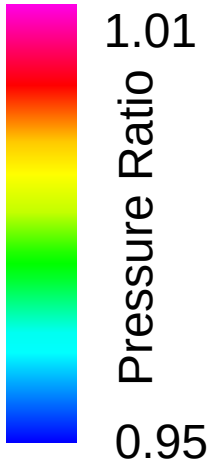




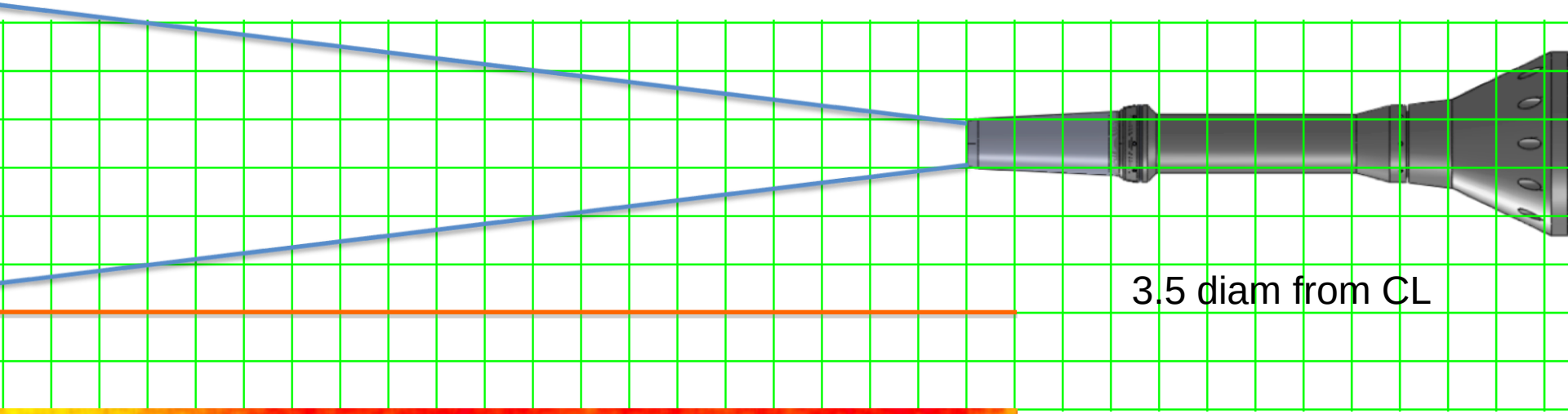
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5

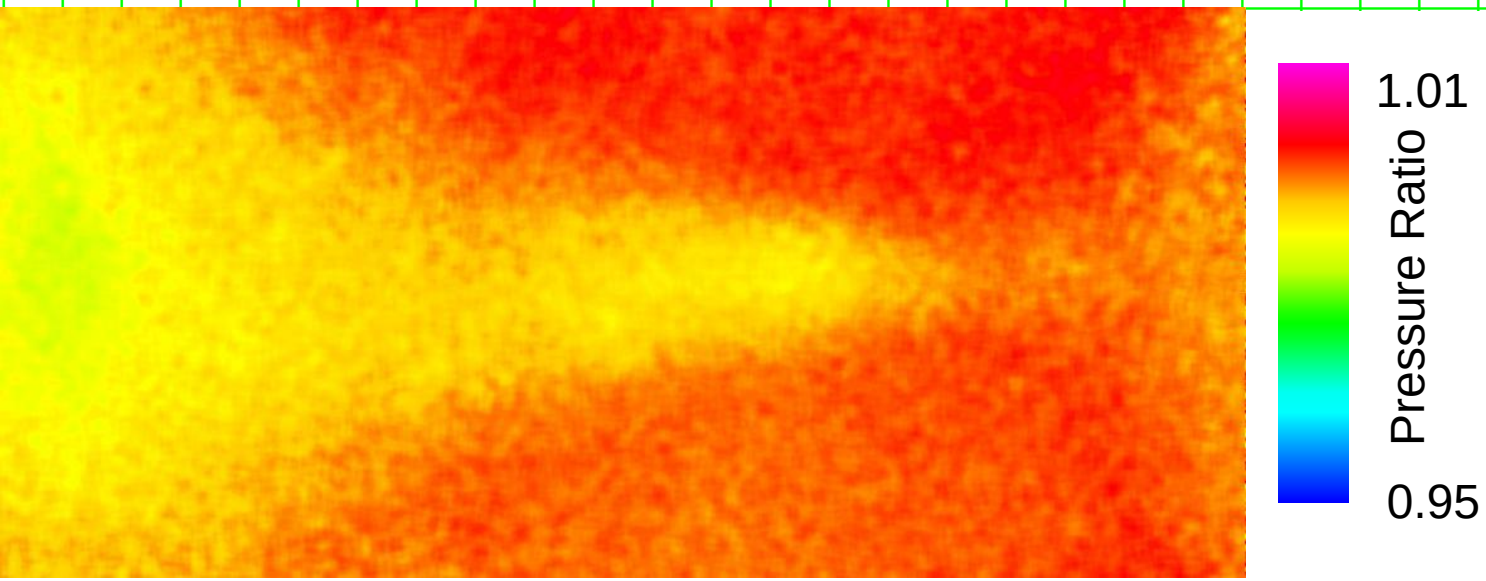




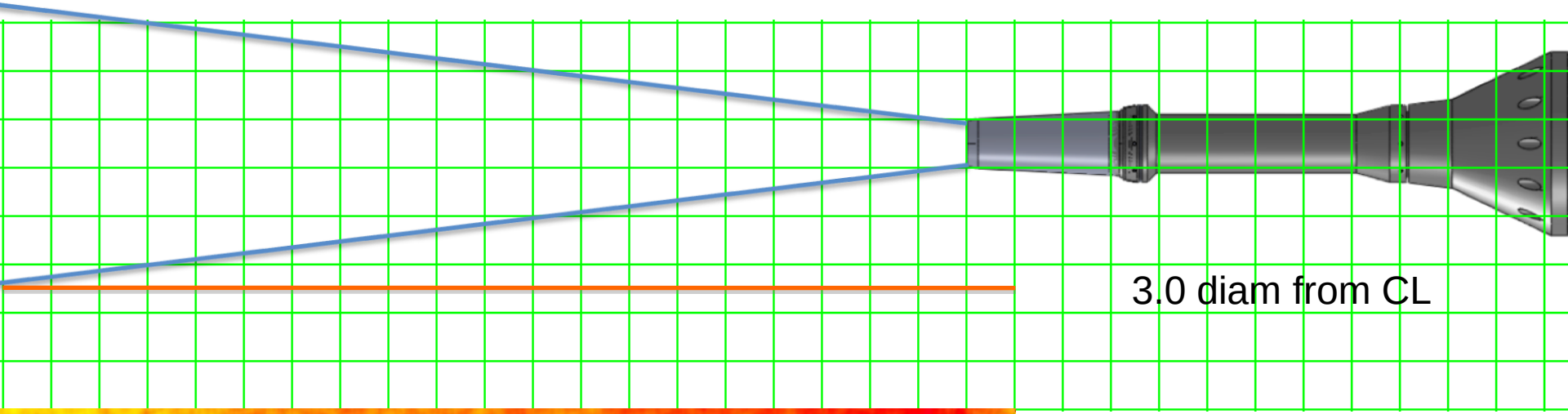


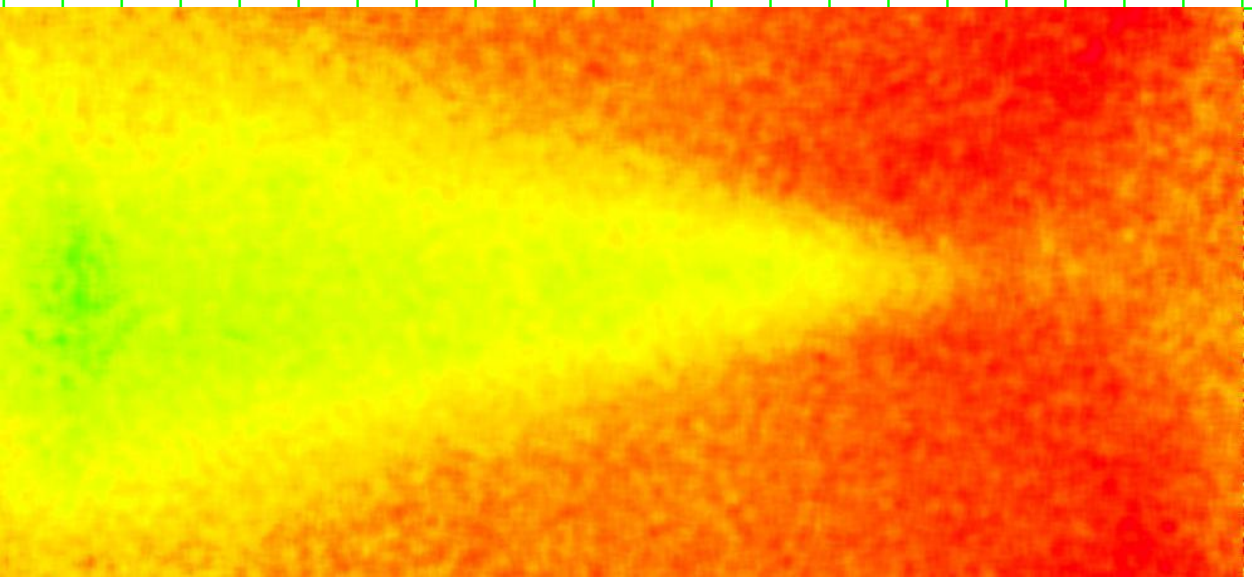
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5

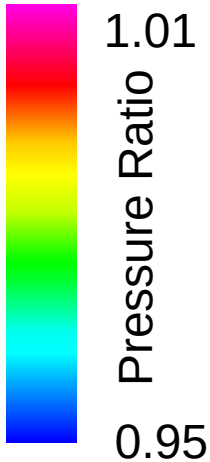




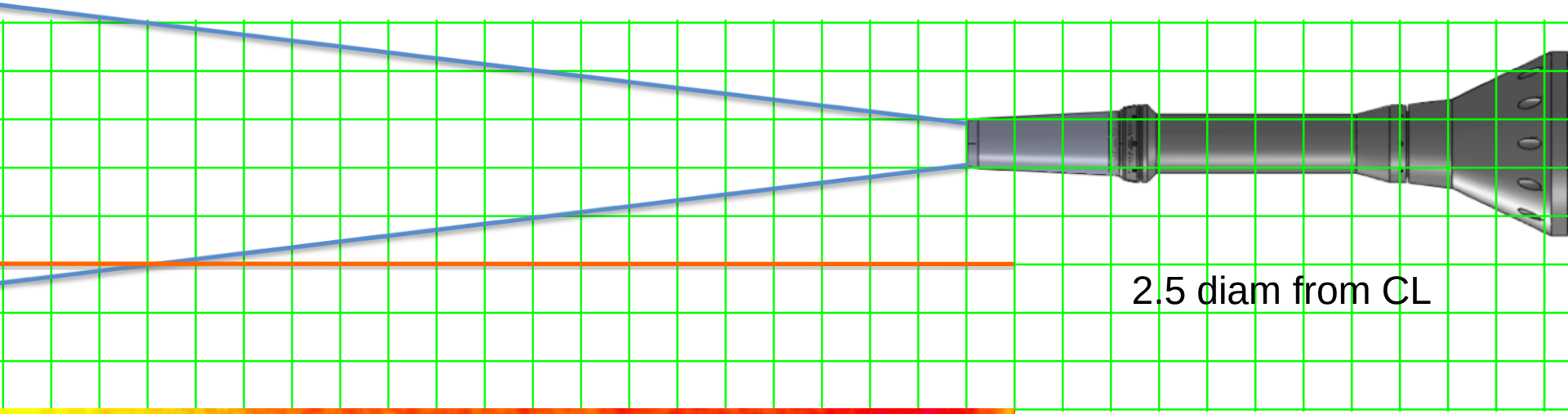
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5

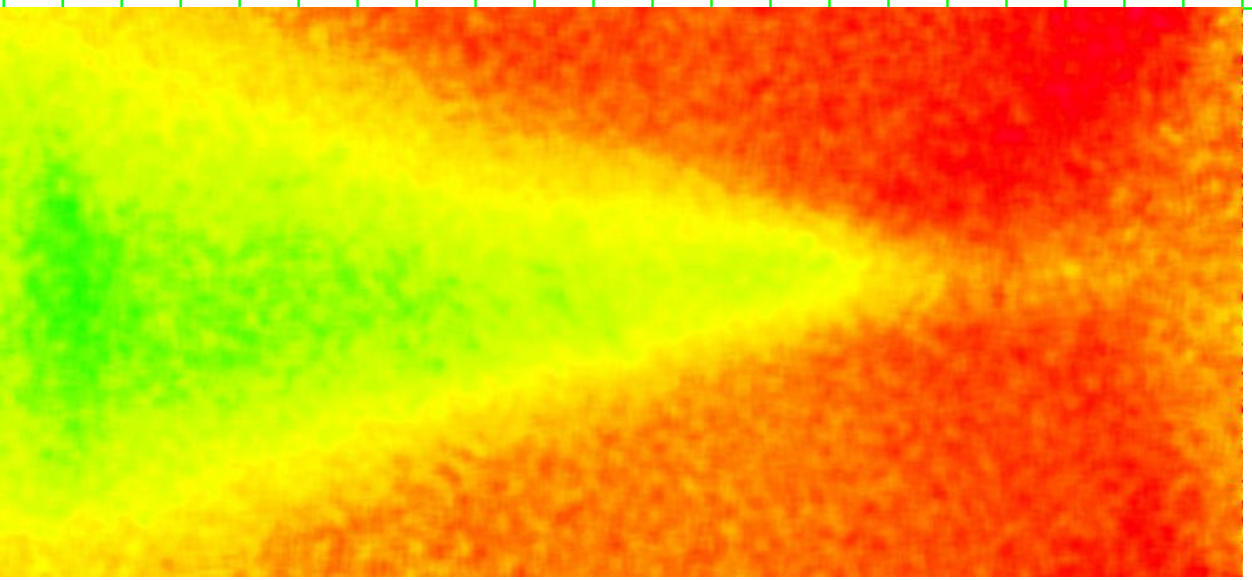


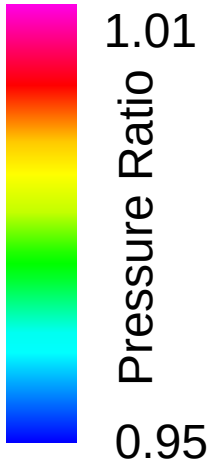




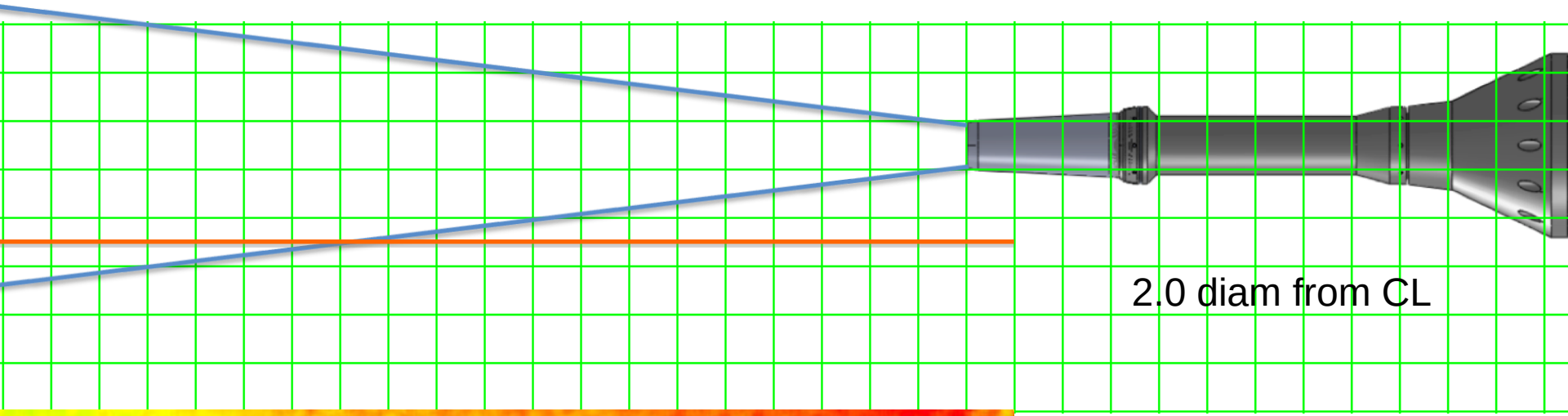
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5



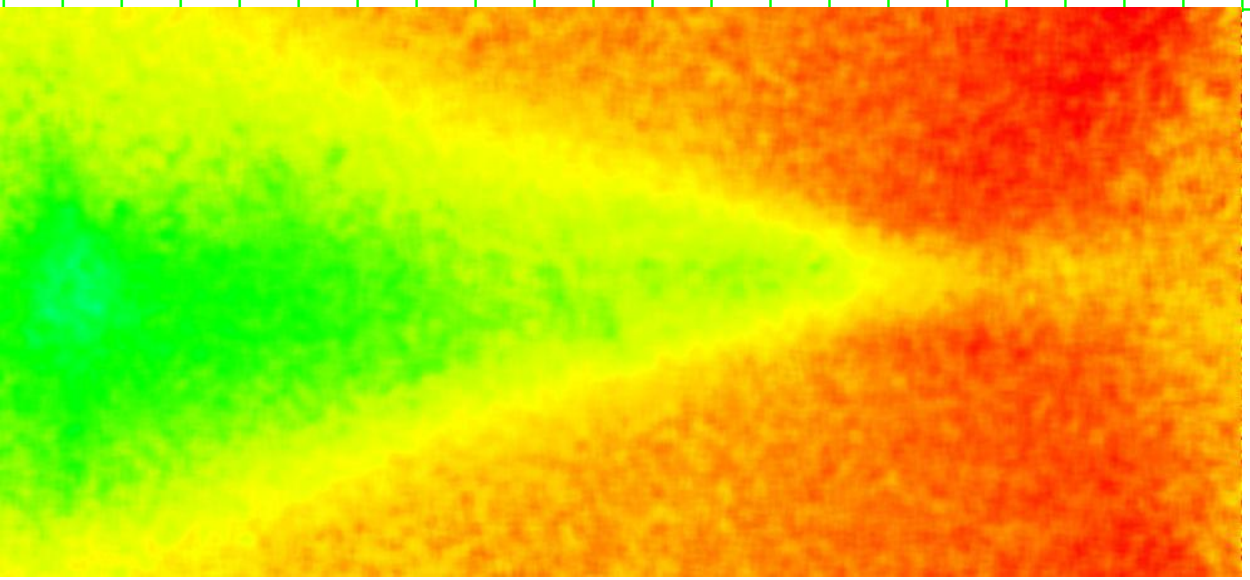


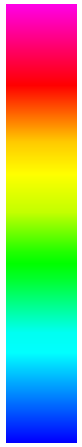


SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5



2.0 diam from CL



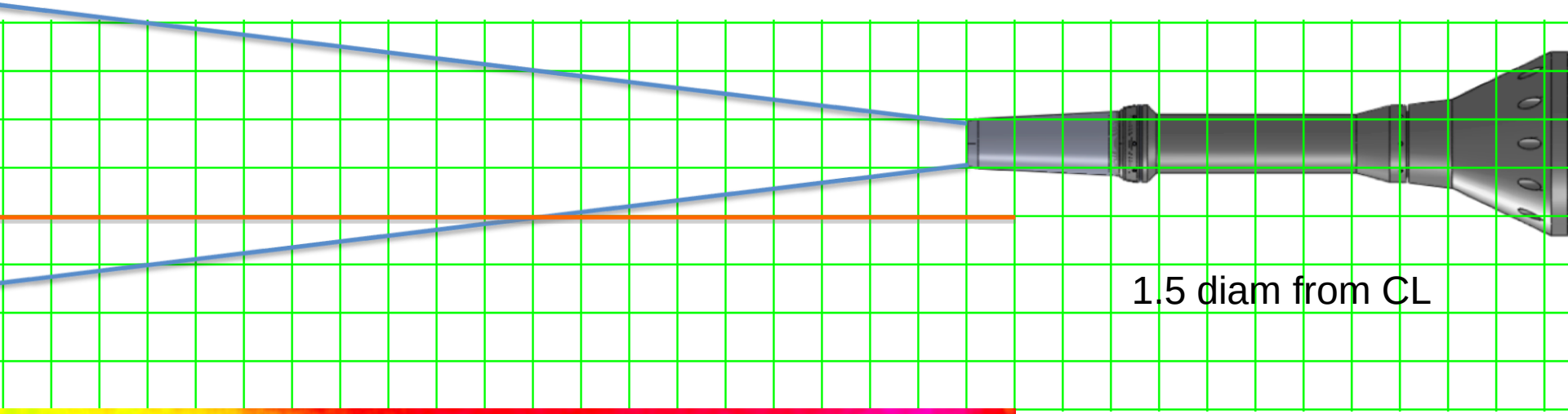


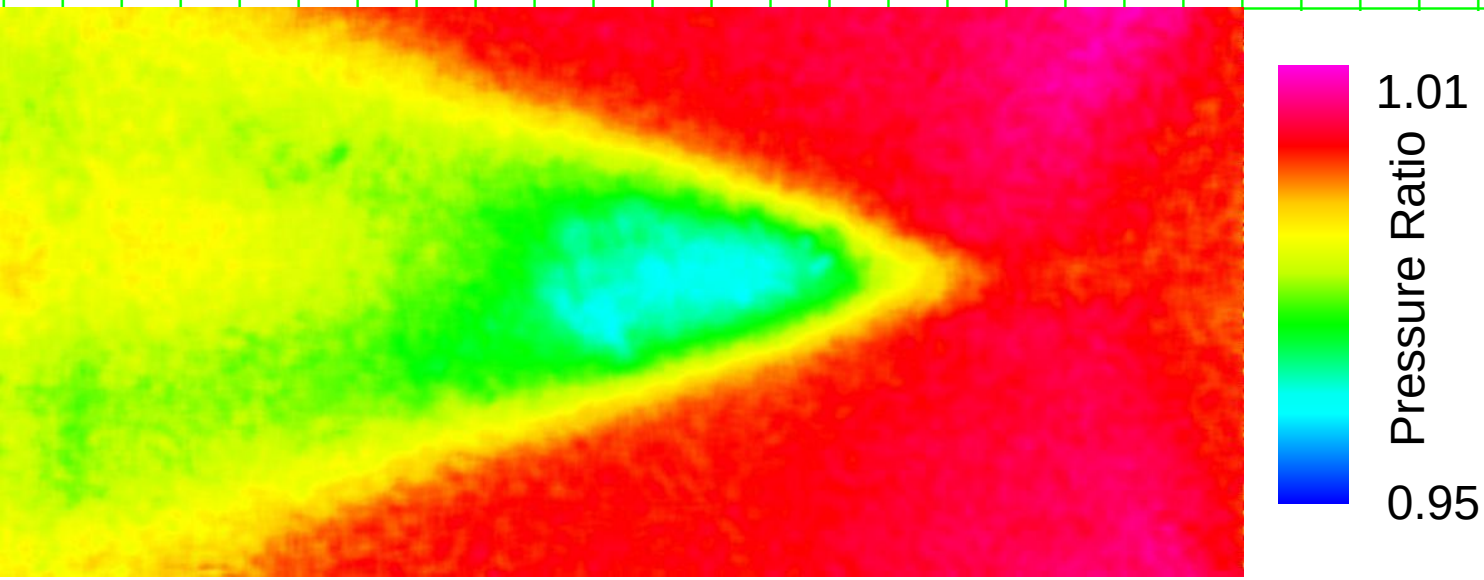
1.01

Pressure Ratio

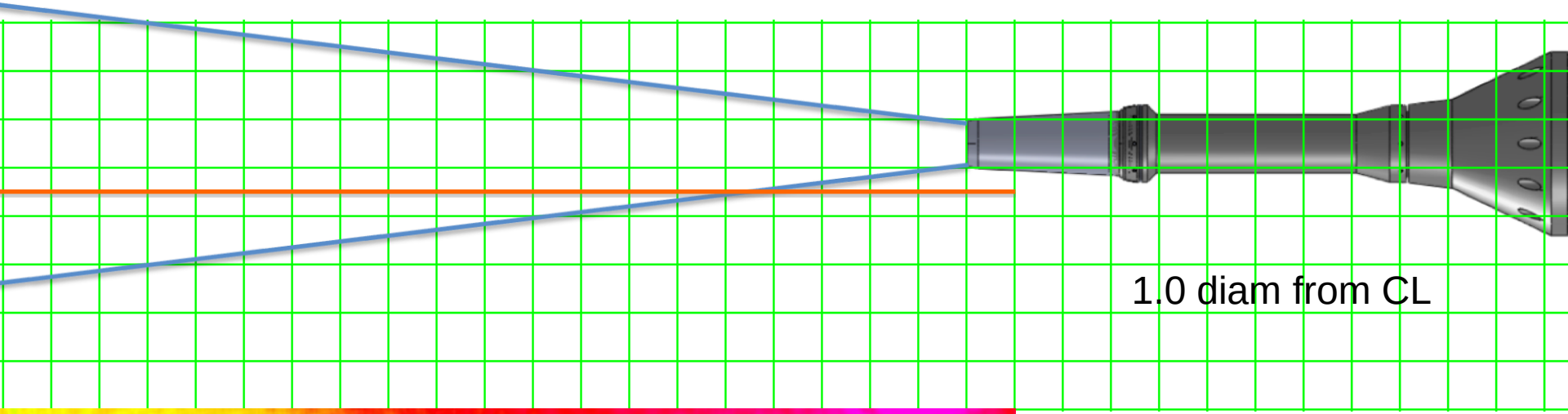
0.95

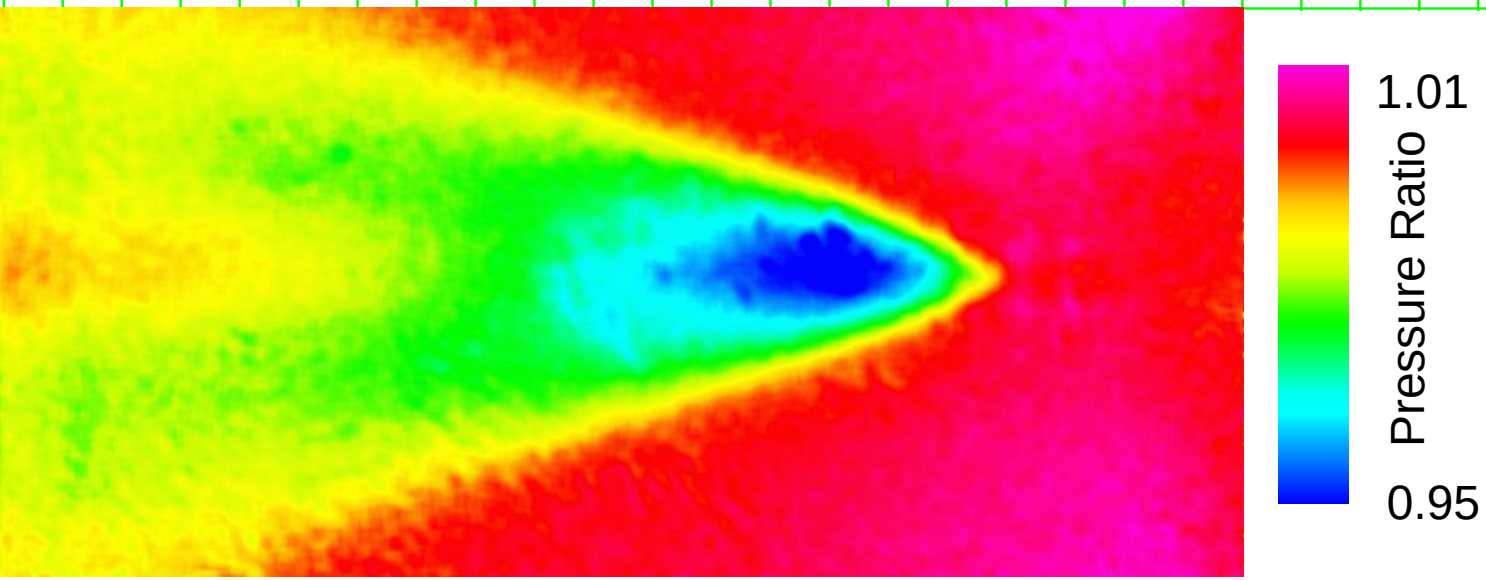
SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5





SMC016 CD Nozzle Set Point 11606 M_{jet}=1.3 M_d=1.5



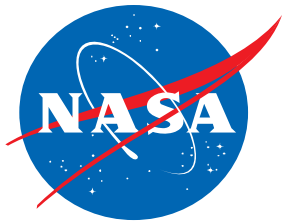


Plans for JSIT2

1) Unsteady surface pressure measurements very close to the surface TE
2) Hot jet data for reflecting surface configurations
3) Shielding surface phased array data with array in the peak noise direction
4) Reflecting surface phased array data both with and without the surface
5) PIV flowfield data near surface TE
6) Rectangular nozzles

Gary.G.Podboy@nasa.gov

Clifford.A.Brown@nasa.gov


NASA